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NASA CR-166742

Dynamics Explorer

Interface Definition Study Final Report

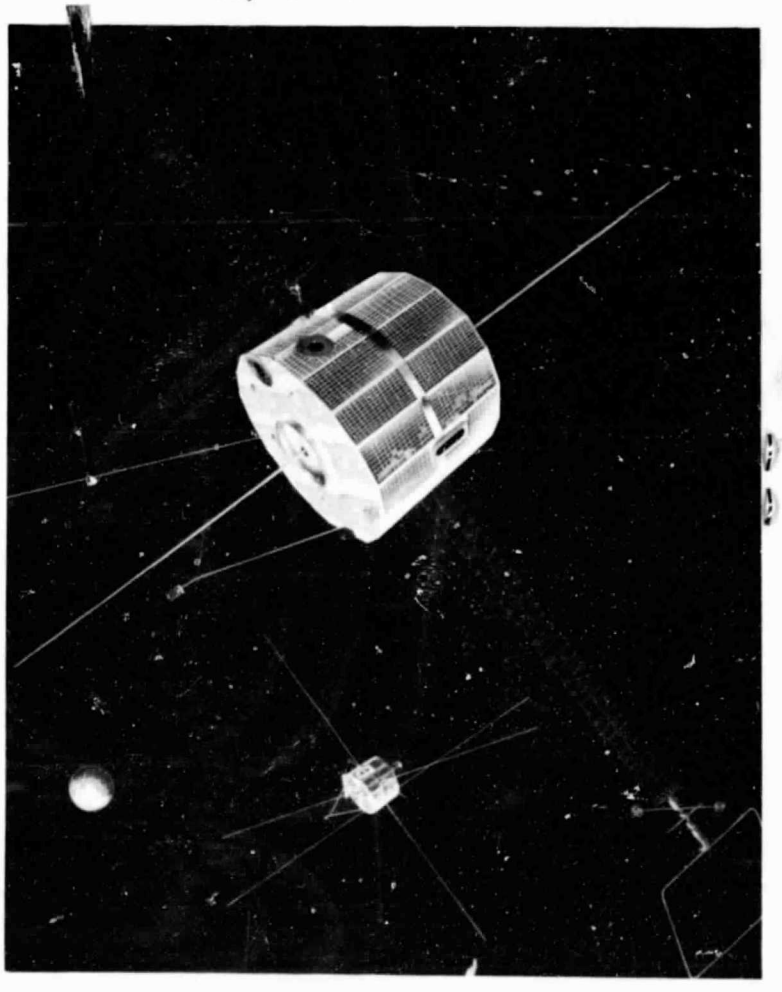
Volume I

October 20, 1978

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Prepared for
National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland



Prepared by
Dynamics Explorer Program Office
RCA Government Systems Division
Astro-Electronics, Princeton, New Jersey

Contract No. NAS5-25020

AE R-4270

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Interface Definition Stu'y
Final Report

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PREFACE

This final report of the Dynamics Explorer Interface Definition Study has been generated by RCA Astro-Electronics in response to the requirements of National Aeronautics and Space Administration Contract No. NAS5-25020.

The final report is submitted in two volumes comprising the following sections:

1.0 Introduction
2.0 Summary and Baseline Change List
3.0 Spacecraft System Design Notes
4.0 Thermal Subsystem Design Notes
5.0 Power Subsystem Design Notes
6.0 Communications Subsystem Design Notes
7.0 Plasma Wave Instrument Interface Definition Design Notes
8.0 Structure Design Notes
9.0 Attitude Control Subsystem Design Notes
10.0 Command and Data Handling Subsystem Design Notes
11.0 Mechanical Drawings
12.0 Reliability Predictions

Sections 1.0 through 7.0 are provided in this volume.

1.0 INTRODUCTION

TABLE OF CONTENTS

Section	Title
1.1	General
1.2	System Specification Changes

SECTION 1.0

INTRODUCTION

1.1 GENERAL

The work performed in response to GSFC-DE-100-017-0, the work statement for the interface definition study, is reported on (in part) in this document. Other deliverable items identified in the work statement are identified in Table 1.

TABLE 1. IDS DELIVERABLE ITEMS

Item	Status	Comments
System Specification Changes	Changes identified	See Section 1.2
Specifications - TX, Booms, SP	Complete	Released to Print File; Scan Platform revisions expected
EMI Test Plan	Complete	Delivered under DE File No. 2.3.3-026, 29 June '78
GIS ECN	Class I ECN Generated	Will be incorporated upon approval notification
MTM Test Plan	Complete	Released to Print File
Instrument UNDOCS	Investigator signature cycle in process	
Antenna Test Plan	Complete	Contained in 3.5.2-004-DN
S/C Preliminary Test Plan	Complete	Delivered with S/C Proposal
Antenna B/B	Delivered	Testing at GSFC initiated

The volume of material contained within this Final Report is the compilation of the work done in response to the work statement wherein a specific deliverable was not identified but where design and analysis tasks were identified. Within each section, a detailed table of contents is provided, listing the design notes which document the work performed.

1.2 SYSTEM SPECIFICATION CHANGES

The changes to the system specification, GSFC-DE-100-020-B, which will be incorporated in revision C are summarized below. These changes, which resulted from design and analytic efforts during the Interface Definition Study (IDS), have been reviewed with GSFC and agreed to during the negotiations for the spacecraft hardware contract modification.

Also included are the agreements in interpretation of the specification. While these agreements do not require changes in the language of the specification, they are included in this summary for completeness. The reference item numbers refer to the paragraphs of Part 2, Book 2, Section 4.0 of the Spacecraft Hardware Proposal, RCA No. 102658-C, 30 June, 1978.

4.1 INTERPRETATIONS

GSFC accepted the following RCA interpretations from Part 2, Book 2:

4.1.1	4.1.12
4.1.2	4.1.13
4.1.3	4.1.16
4.1.4	4.1.19
4.1.5	4.1.21
4.1.6	4.1.22
4.1.11	4.1.23

In addition, the following agreements were reached on the remainder of the interpretations.

4.1.7 Revision B of 100-020 changed the words "maintaining" to "detecting" such that the paragraph now reads:

"3.4.3.2.5 DE-A Horizon Sensing

The DE-A spacecraft shall contain earth horizon sensors oriented to produce an indication of the earth to sky and sky to earth transitions and earth chord widths as seen by the horizon sensors.

The sensors shall be capable of detecting the deviation of each edge of the earth crossing envelope pulse relative to a local vertical reference direction to within $\pm$ 0.2 degrees due to variations in mission operational orbit spin rate, sensor noise, and earth radiance variations. In addition, the sensors shall be capable of being aligned with respect to the spacecraft spin axis to within $\pm$ 0.1 degrees."

4.1.8 GSFC understands the interpretations. RCA has agreed to provide data on the sun sensor masking and effects on system capability.

4.1.9 Revision B of 100-020 changed "maintaining" to "detecting" such that the paragraph now reads:

"3.4.3.3.5 DE-B Horizon Sensing

The DE-B spacecraft shall contain earth horizon sensors oriented to produce an indication of earth/sky horizon transition and earth chord widths. Mechanical scanning shall be provided for the sensors by rotating component of the momentum wheel assembly. The sensors shall be capable of detecting the deviation of each edge of the earth crossing envelope pulse relative to a local vertical direction to within $\pm$ 0.2 degrees due to variations in mission operational orbit, mechanical rotational characteristics of the MWA, sensor noise, and earth radiation variations. In addition, the horizon sensors shall be capable of being aligned with respect to spacecraft spin axis to within $\pm$ 0.1 degree."

With respect to attitude determination accuracy, working meetings have been held with RCA, CSC and GSFC personnel in attendance. There has been a basic concurrence from CSC with RCA's position on the performance characteristics of the proposed sensors (REF: W. Fuldner to R. deBastos, Trip Report DE file 1.9.1-056 dated Oct. 2, 1978).

4.1.10 Same comment as 4.1.8.

4.1.14 Revision B of 100-020 changed the wording of Paragraph 3.4.5.6.6 from "n x 8 (n = integer 8)" to "n x 8 (in less than or equal to integer 8)". The paragraph now reads:

"3.4.5.6.6 Digital Words Format

Digital telemetry words of n x 8 (n less than or equal to integer 8) bit length which are assembled into the serial telemetry output of the spacecraft shall be provided."

4.1.15 The oscillator stability requirement was agreed to be "one part in 10^5 not including the initial frequency offset". Paragraph 3.4.5.6.8 of GSFC-DE-100-020 will be changed to reflect these words.

4.1.17 RCA submitted the following substitution for the 4.1.17 interpretation:

"4.1.17 DE-A Operational Requirements (Specification paragraph 3.4.6.2)

The proposed system, in conjunction with incorporation of the 70-rpm third state spin rate, demands that the DE-A S-band antenna be erected under internal spacecraft control subsequent to the

interstage adapter and prior to the 70-rpm spin-up maneuver. This results in the following antenna coverage:

At apogee and at perigee, the link performance will be as in the link tables regardless of the Z-axis orientation. When not at apogee or perigee, link performance will be degraded by an amount which depends on the orientation of the Z-axis. The worst-case will occur when the Z-axis lies in the orbit plane. In this case, approximately 75% of the orbit period will be available for commanding, 60% for ranging, and 50% for HEW telemetry. The contact time will be centered near apogee. There also will be a brief contact interval (approximately 2 minutes) near perigee.

As the precession maneuver moves the spin axis from the orbit plane to the operational orientation, the coverage capability increases until the operational capability as shown in the proposal is achieved.

RCA interprets the specification requirements to allow for the partial coverage during the turnaround maneuver as noted above to be acceptable."

This interpretation was acceptable to GSFC.

4.1.18 RCA understands that the test referenced will be done at GSFC, and that the Building 11 Sigma 5 computer will be used and is compatible with the software. The OCC may or may not be used.

4.1.20 RCA has agreed that the interpretation as contained in the proposal be modified to read:

"4.1.20 Magnetic Field (Specification Paragraph 4.2.7)

This specification invoked a measurement of magnetic signatures under worst case switching conditions. This measurement may be made while the spacecraft is illuminated and spun in the GFE facility."

4.1.24 RCA and GSFC agreed that the booms would not be extended in thermal-vacuum, but the instruments and booms are to be electrically functional within the physical constraints of the chamber.

4.2 <u>DEVIATIONS</u>

4.2.4
4.2.5
4.2.6 (Rev. B of DE-100-020 changed wording)
4.2.7 (Rev. B of DE-100-020 changed wording)

The following agreements were reached on the remaining exceptions:

4.2.1 RCA accepted the specification requirements of Paragraph 3.1.7 which requires internal operating equipment mounting surface temperatures to be maintained within the limits of 0° to 25°C for both spacecraft.

4.2.2 With respect to specification paragraph 3.4.2.4(b), the same comment as that of 4.2.1 applies.

4.2.3 GSFC agreed with the proposed C/4 charge rate. Paragraph 3.4.4.2.2 will be changed accordingly by GSFC.

4.3 EXCEPTIONS

GSFC accepted the following exceptions:

4.4(a)	4.4(f)
4.4(b)	4.4(g)
4.4(c)	4.4(h)
4.4(d)	4.4(i)

With respect to the remaining exceptions, the following agreements were reached:

4.4(e) RCA agrees that the GSFC Reliability and Quality Engineer will sign off on the Standard Repair MRB. This will be accomplished via the submittal to GSFC, for approval, of Standard Repair MRB.

4.3.1 GSFC agreed to change Paragraph 3.1.3.2.1 to specify a DE-B minimum duty cycle of 16 percent, with a design goal of 19 percent. RCA will present at the Spacecraft CDR or earlier a total definitized plan which shows how we will meet the specification requirement.

4.3.2 RCA accepted the specification requirements of 0° to 25°C. (See comment on 4.2.1.)

4.4 ADDITIONAL CHANGES

Subsequent to the proposal, RCA submitted an exception to the 70-dB requirement of Paragraph 3.4.6.1.1. It was agreed that this sentence would be deleted from that paragraph.

At the negotiations, RCA pointed out that the battery temperature requirements of Paragraph 3.4.4.2.6 were inconsistent with the spacecraft thermal operation of 0° to 25°C. Accordingly, RCA requested that Paragraph 3.4.4.2.6 be modified. On October 18, 1978, RCA and GSFC agreed that the last sentence of Paragraph 3.4.4.2.6 be changed to read: "The batteries shall be maintained in flight between 0° and 25°C, with occasional excursions to 30°C."

Several agreements were reached with respect to revised paragraphs in RCA specification PS-2295108. These agreements also required similar changes to GSFC-DE-100-020. The affected paragraphs of 100-020 are:

4.2.7	5.3.3.5(f)
5.3.3.5(b)	5.3.3.6

The changes to the above paragraphs are as follows:

Para. 4.2.7 Change the last sentence to read: "Spacecraft magnetic signature under worst case switching conditions shall be measured to determine if the DE spacecraft magnetic goals are achieved."

Para. 5.3.3.5(b) Change to read: "Operation of the spacecraft in the launch mode throughout pumpdown; including monitoring for electrical discharge."

Para. 5.3.3.5(f) Add the words "and levels" between "test configuration" and "as required."

Para. 5.3.3.6 Change the third sentence to read: "Under these conditions, a simulation of all instruments operating in concert shall be accomplished."

Subsequent RCA-NASA agreements were reached which provided the following changes:

Add a new Paragraph 3.6.2.3 as follows:

"3.6.2.3 Software and Instrument Test Support

Contractor shall participate in the development of the I&T software systems, its applications programs, and its test procedures. As a result of this participation, the contractor shall develop the capability to perform and evaluate routine tests (EPETS) of the instrument complement as well as adapt the EPETS for use during system level test. The contractor

shall develop, perform, and evaluate all system level test procedures and shall have a depth of knowledge sufficient to allow reliable fault isolation to a component or instrument level."

Para. 3.4.6.5.1(b)2

In Para. 3.4.6.5.1(b)2, change "± 45 degrees" to "± 44 degrees". (This change is covered in the Deviations noted in Proposal Paragraph 4.2.5.)

2.0 SUMMARY AND BASELINE CHANGE LIST

SECTION 2.0

SUMMARY AND BASELINE CHANGE LIST

As indicated by the list of deliverables and by the topics addressed in the design notes, the Interface Definition Study (IDS) effort was directed primarily toward refining the detail knowledge of the system design, especially as it affects the interfaces of the spacecraft with the instrument complement.

Significant effort was spent in attempting to accommodate all of the instrument field-of-view requirements to establish instrument placement within the spacecraft and in establishing the system thermal design to provide a viable thermal environment for the instruments. The system performance was enhanced with the change to higher efficiency solar cells. In the area of communications, additional supportive analyses were performed and brassboard models of the three antennas to be used on the spacecraft were fabricated and delivered to GSFC to permit timely antenna testing. Detailed analyses of the elements of the Attitude Control System were performed, and the results were incorporated in a combined analysis with CSC (Computer Sciences Corp.) to assess the overall attitude determination performance which can be provided for the mission science. These analyses are continuing beyond the completion of the IDS.

The results of the work done to date have resulted in the following list of design tradeoffs and system changes which are yet to be performed.

1. Scan Platform Design Approach

   A change from the proposed stepper motor and bearing assembly to a bearing and motor assembly similar to the MWA enhances the mechanical design. The effects of such a change to the electrical performance are presently under evaluation.

2. MWA Mirror Angle

   Change from the baseline to a single scan angle of 50° simplifies the equipment design and offers improvements in attitude determination accuracy.

3. Solar Cell Cover Glass Thickness

   Departure from the baseline 60-mil glass offers a weight advantage. The alternate glass thickness must yet be correlated with the program radiation policy.

4. S-Band Power Amplifier

Evaluation of the impact to system performance by the addition of a 10-watt power amplifier has yet to be performed.

5. Dual Crystal Oscillator

The assessment of the impact to make the crystal oscillator redundant has yet to be performed.

6. Dual Microprocessor

Same status as item 5. (Note that these two items are closely interrelated.)

7. Two-Bit Rate Command Link

The assessment of impact to utilize the two-command-rate feature of the transponder has yet to be performed.

8. Two-Speed Playback Rate

Same as item 7.

9. EMI Fixes

The impact to the hardware will be assessed for the major fixes to the system design when the "fix list" is specified.

10. Delta Interface

The system design has been modified to eliminate the requirement to impart system momentum to the DE-B spacecraft by rolling the second stage in favor of starting the momentum wheel from a signal generated in the DIGS.

3.0 SPACECRAFT SYSTEM DESIGN NOTES

TABLE OF CONTENTS

Design Note	Title
2.2.2-004-DN	DE-A Acquisition Sequence
2.2.4-001-DN	DE-A Nadir Generator Error Sources
2.2.4-003-DN	Spacecraft Launch Configuration and Initialization
2.3.3-023-DN	Considerations Affecting the Implementation of Solar Cell Bypass Diodes and Resulting Solar Array Output Noise
2.4.1-004-DN Rev. H	Dynamics Explorer Weight Report DE-A
2.4.1-005-DN Rev. H	Dynamics Explorer Weight Report DE-B
2.4.1-013-DN	DE-A and -B Spacecraft Configuration and Mass Properties
2.4.4-003-DN	DE Radiation Environment Analysis

Design Note

RCA Astro Electronics Division

Originating Project or Group	Note No.
Dynamics Explorer	2.2.2-004-DN

Title

DE-A Acquisition Sequence

Written by: C. Hubert	Date June 1, 1978
Approved by: W. Fuldner	Date June 1, 1978
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	Send one copy of this Note to the DCC (Library) attached to a copy of Form AED 1488.

REVISIONS

Letter	Description	Date	Author

The proposed acquisition sequence is based on the assumption that the spacecraft core spin axis inertia is 50 slug ft^2, the wire tip masses are 4.5 grams each, and the experiment booms are 9 in. diameter Astromasts. Variations of these parameters will affect the numbers presented, but the basic sequence of events should not change.

In the following discussion, recall that minimum wire tension occurs at the tip and maximum tension at the base.

Sequence of Events

(1) Separate from the launch vehicle with a 40 rpm spin rate. This rate is the minimum achievable and was chosen in order to minimize the time required for the precession maneuver (event 3). This results in quicker acquisition of a favorable thermal environment, antenna coverage of earth throughout the orbit, and complete attitude determination throughout the orbit.

(2) Deploy the S-band antenna. The timing of this event is not firm and it may occur prior to separation.

(3) Magnetically precess the spacecraft angular momentum vector to the orbit normal.

(4) Blow off all instrument covers. This event will occur at or shortly before the end of the precession maneuver. The timing provides in excess of 10 days for outgassing before the instruments are exposed.

(5) Deploy the first 45 meters of the PWI wire antennas. This will approximately double the spin-axis moment of inertia and drop the spin rate to 19.6 rpm. The maximum wire tension during this phase of deployment will be 517 grams, occurring at a deployed length of approximately 35 meters. The minimum

wire tension will exceed 17 grams for deployed lengths greater than 1.5 meters.

(6) Spin-up to 25 rpm.

(7) Deploy the first three meters of the experiment booms. The spin rate will drop to 10.3 rpm. A maximum boom tension load of approximately 12 lb will occur during this phase of deployment.

(8) Spin-up to 20 rpm. The tension at the base of the boom will rise to 26 lb.

(9) Complete experiment boom deployment. A spin rate of 10.5 rpm results.

(10) Spin up to 19 rpm. This represents slightly less than the final momentum. The experiment booms will experience tension loads of 36 lb (the greatest load applied during the acquisition sequence).

(11) Complete wire antenna deployment. The peak wire tension load will be 624 grams and will be experienced at approximately 74 meters of deployed length. This represents the greatest tension experienced by the wires during the acquisition sequence. The spin rate will be reduced to 9.6 rpm.

(12) Spin up to 10 rpm. The final spin-up is performed after wire deployment to avoid possible overshoot.

(13) Deploy the spin axis tubular antennas. This event is scheduled last to minimize potential destabilizing effects.

The following table compares various requirements with the performance achieved by following the proposed sequence.

PERFORMANCE VS. REQUIREMENTS

		Requirements	Performance
Wire Antennas	Tension Upper Bound	8.0 lb	1.4 lb
	Tension Lower Bound	17 grams (after first few feet of deployment)	17 grams after 5 ft
	Number of Deployment Motor Starts	As few as possible	2
Experiment Booms	Maximum Spin Rate During Deployment	25 rpm	25 rpm
	Number of Deployment Motor Starts	As few as possible	2
	Maximum Tension Load		36 lb
Earth Sensor	Maximum Spin Rate	70 rpm	40 rpm
	Minimum Spin Rate	9 rpm	9.6 rpm
Scientific Instruments	Outgassing Time Before Exposure	At least 2 or 3 days	At least 10 days

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 2.2.4-001-DN

Title

DE-A Nadir Generator Error Sources

Written by: W. V. Fuldner	Date 27 Sept '78
Approved by:	Date 10/10/78
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

Letter	Description	Date	Author

Standard Distribution:
W. Hord (NASA)
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D. Shipley
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INTRODUCTION

This design note describes the operation of the nadir generator as it presently exists and provides a detailed error analysis of it. Reference (1) and (2) present the recently identified desires of the SAI instrument for accuracies of the nadir pulse generator to permit the present configuration of the instrument to obtain global auroral images. Table I summarizes the present spacecraft capabilities for nadir generation and Table II compares system performance with the SAI requirements.

DISCUSSION AND ANALYSIS

When mounted on the spacecraft (S/C), the optical axis of the body mounted horizon sensor (BMHS) will nominally lie in a plane which is normal to the X-Y plane of the S/C and θ_0 degrees away from the +Y axis as shown in Figure 1. Therefore, if it could be determined when the sensor optical axis passes through the nadir plane, it is known that S/C +Y axis would pass through nadir T_0 seconds later, where $T_0 = \theta_0/\omega_B$ and ω_B is the S/C body rate. Since it is not known in "real time" when the BMHS actually crosses nadir, but only when it makes sky-earth and earth-sky crossings, spacecraft +Y at nadir must be determined either as a lag of $T_0 + \frac{t_e}{2}$ seconds from the BMHS sky-earth transition or as as a lag of $T_0 - \frac{t_e}{2}$ seconds from the BMHS earth-sky transition, where t_e is the earth crossing time of the sensor. The former technique is the one used in the hardware implementation of the nadir generator.

In the implementation of the nadir pulse generator, two time counts are initiated as the BMHS makes a sky-earth transition (see Figure 2). The first (waveform B in Figure 2), which is driven by a 1024 Hz clock, counts the sensor earth crossing time, t_e; the second (waveform C in Figure 2), driven by the S/C body clock, produces a count at each degree of body rotation. The earth time counter continues to count until the BMHS has an earth-sky transition, and holds its count, corresponding to t_e, until the body counter reaches a count of θ_0. At this point the spacecraft +Y axis is nominally directed toward the sky-earth transition as shown in Figure 2. The t_e counter then counts down, driven by a 2048 Hz clock, reaching zero when the spacecraft +Y is along nadir. At this point, the nadir reference pulse (waveform D of Figure 2) is generated.

The accuracy of the nadir pulse so generated is a function of the altitude and rotation rate of the spacecraft. Table 1 provides the error summary for the case of the S/C rotating at 10 rpm. As seen in the table, the error contributors are distributed into three categories as follows: random errors, secular errors, and sensor bias errors.

Table 1.

Nadir Pulse Errors at a 10 rpm Spin Rate

Error Source	Worst case error - Degs	RSS Error Deg
I. Random Errors		--
Earth Time Threshold Jitter	0.164	
Spin Period Threshold Jitter	0.146	
Earth Time Clock Resolution	0.0879	
Spin Period Clock Resolution	0.052	
*RSS_1		0.271
II. Secular Errors		
Earth Time Sample Rate - Δh	-0.0035	
Spin Period Sample Rate - Δh	0.030	
Earth Time Sample Rate - $\Delta\phi$	-.0070	
Spin Period Sample Rate - $\Delta\phi$	+.060	
Direct Sum		0.083
III. Sensor Bias Errors		
Threshold Drift	0.036	
Horizon Variation	0.120	
Earth's Oblateness	0.200	
Sensor Azimuth Alignment	0.1	
Dynamic Lag Calibration Uncertainty	0.2	
**RSS_2		0.325
Error Summation	$\pm$1.18	$\pm$0.68

$$*RSS_1 = \sqrt{(0.164)^2 + (0.146)^2} + \sqrt{[0.5\,(0.0879)]^2 + [0.5\,(0.052)]^2} = 0.283$$

$$**RSS_2 = \sqrt{(0.036)^2 + (0.120)^2 + (0.200)^2 + (0.1)^2 + (0.2)^2} = 0.325$$

Table 2. Summary of SAI Nadir Requirements vs Spacecraft Performance

SAI Requirement	System Performance	Comment
Orientation Spin vector motion $<0.25^{o}$ p-p in 10 min.	Will meet requirements	Independent of Nadir performance. Function of total system momentum.
Rate Instantaneous rotational position $<0.12^{o}$ in 12 seconds.	Peak variation in angular position $= 0.165^{o}$ in any one 12 second interval	Assumes worst case reinforcement of thermoelastic induced body motion from successive eclipse exits.
Azimuth Nadir pulse (not a phase shifted nadir) measured to within $\pm 0.12^{o}$ once per revolution	Short term RSS accuracy = $\pm 0.36^{o}$ long term RSS accuracy = $\pm 0.68^{o}$ Note: The accuracy for a phase shifted Nadir will be worse than the above.	Short term = RSS random + secular errors of Table 1. Long term = Short term + sensors bias error. Long term worst case number includes all factors at perigee operation.

- Random Errors - Random errors in nadir reference generation are produced by noise on the BMHS signal and the resolution of the various clocks.

1) BMHS Noise (Threshold Jitter) - Body horizon sensor noise produces jitter in the sky-earth and earth-sky edges of the earth envelope pulse (Figure 2, waveform A), therein inducing errors in both the spin period measurement which is used to control the body clock and the earth time measurement, t_e. Earth time measurements are affected by threshold jitter on both the sky-earth and earth-sky transitions. However, due to the nature of the generation scheme, the largest error in the nadir pulse location due to threshold jitter on the t_e measurement is the same as the largest error for a single threshold. The worst case threshold error, equal for both sky-earth and earth-sky transitions, is a function of the sensor noise level and the rate of S/C rotation. At a 10 rpm body rate, the worst-case threshold jitter amounts to 0.164^0 (at perigee), based upon the specified worst case 6:1 threshold to zero-to-peak noise ratio (See attachment (1) for noise calculations).

Referring to the 30 August memo (Reference 2), page 3, under the heading "comments": RCA concurs that the earth horizon sensors should be able to determine the earth horizon to within $\pm 0.2^0$. This was substantiated by the calculations presented to Iowa on 7 August during my visit there when the scan to scan jitter calculations (attachment 1) were presented which identified the scan to scan worst case jitter, due primarily to threshold to noise considerations, as $\pm 0.152^0$ at apogee and $\pm 0.164^0$ at perigee. As was noted at the time of the discussions, the shape of the distribution was not known and we recommended not treating the number as "n sigma" value. Subsequent to the discussions we verified that the analytic model did not utilize a simplifed "step input" horizon, but did convolve the sensor field of view with a representative analytic model of the CO_2 horizon. The horizon model was extracted from "The Analysis of 15 micron Infrared Horizon Radiance Profile variations over a range of Meteorological, Geographical, and Seasonal Conditions", NASA CR-725, April, 1967.

Additional investigations to date as to the nature of the distribution of the errors has indicated that they result primarily from thermal noise, which is assumed to have a gaussian distribution, and $\frac{1}{f}$ noise, which does not. Since the horizon sensor is AC coupled, the $\frac{1}{f}$ contribution of the $\frac{1}{f}$ noise will probably be small compared to the thermal noise and a gaussian distribution may be assumed. No empirical information is available to adequately characterize the noise and jitter distributions. The numbers used in the jitter analysis represent a worst case threshold to noise value. Thus, extrapolation back to a one sigma value, while probably a reasonable "guess", can only be done at ones own risk.

Spin period measurements are affected by the jitter on successive sky-earth transition thresholds. At 10 rpm, this amounts to a worst case error of 0.328 degrees (at perigee) per S/C rotation. However, the contributing error to the nadir reference pulse is $\theta_0/360$ times the error for an entire revolution. For this analysis, a value of 160 degrees was employed for θ_0. This value is based upon the sensor's current design location on the S/C and certain calibration considerations.

2) Clock Resolution - There are essentially four clocks that are used in generating the S/C nadir reference pulse. These are the 1024 Hz and 2048 Hz clocks associated with the earth time up-down counter, -- the 131,072/360 Hz clock used to measure the S/C spin period and control the body clock, and the body clock which emits a pulse for every degree of S/C rotation.

Resolution errors in the earth time measurement are incurred at the sky-earth and earth-sky transition, i.e., at the start and end of the count up, and at the start of the double frequency count down (circled points Figure 2, waveform B). Since the counter contains an integral count after the sensor has crossed the earth, there is no resolution error at the end of the count down. At the 10 rpm body rate, the 1024 Hz clock has a resolution of 0.0586 deg/count, and the 2048 Hz clock has a resolution of 0.0293 deg/count.

Resolution errors in the spin period measurement are incurred at the start and the end of each count. At the 10 rpm body rate, the 364.1 Hz clock has a resolution of 0.165 deg/count, resulting in an error of 0.117 degree per S/C revolution. Again, this must be multiplied by the factor $\theta_0/360$ to obtain the error in the nadir reference pulse.

In the nadir generator, the body clock is used to determine when the S/C has rotated θ_0 degrees after the BMHS has a sky-earth transition. Since the body clock, which has a one degree resolution, is synchronized to the sky-earth transition threshold and since θ_0 is an integral number of degrees (160), it contributes no resolution error to the nadir reference pulse. It will contribute an error, however, in the phase shifted reference pulses supplied to the instruments as discussed below.

Assessment of the error introduced by the digital precision of the nadir generator has indicated the following:

Reference clock used	Worst case error at 10.000 rpm
131 kHz	0.165^0 (baseline system design)
262 kHz	0.0825^0
512 kHz	0.0413^0 (upper limit allowable without major impact to CTP design)

Note that the worst case error is a linearly increasing function throughout one rotation of the spacecraft with the worst case error occurring at the 359^0 nadir pulse.

- Secular Errors - Errors in both earth type measurements and spin period measurements are produced as a result of S/C altitude changes and body rate changes, and also when there is a roll rate on the S/C. The errors are not random in nature, but rather add algerbraically.

1. Altitude Change - Altitude change, as the S/C proceeds around in orbit, produces errors in the earth time and spin period measurements which are partially self compensating. The effect is best understood by considering a specific case as that of increasing altitude shown in Figure 3. Referring to Figure 3a, the BMHS makes a sky-earth transition at S/E and an earth-sky transition at E/S. The E/S point is moved into the smaller, dotted circle (earth) since the earth appears slightly smaller at the higher altitude achieved during the crossing. The earth time count will then be the time required for the sensor field-of-view (fov) to pass between these two points. Since the double frequency count down is initiated θ_0/ω_B seconds after the sensor sky-earth crossing, when spacecraft +Y is directed in space towards S/E, the nadir pulse (N_A) will occur at a point which is short of the true nadir (N_T).

   For the spin period measurement, a count will begin when the sensor makes a sky-earth transition (S/E_1 in Figure 3b) and end on the following sky-earth transition (S/E_2). Since the earth has appeared to shrink in the time interval between the two transitions, the spin period count will be slightly larger than the actual spin period. Thus when the body clock counts the θ_0 degrees after the sky-earth transition, the S/C will have rotated through an angle greater than θ_0 which will tend to delay the start of the double frequency t_e count down and shift the nadir pulse toward earth-sky (N_A toward N_T in Figure 3a).

   Thus it is seen that the earth time and spin period counts do partially compensate for one another when the S/C altitude is increasing. The effects are simply reversed when altitude decreases, with the errors again partially compensating.

   The systematic rate of change of the scanned earth, as a function of the DE-A spacecraft altitude is addressed in the computer generated plots 1, 2, and 3. (Attachment 3). These three plots display theta, the true anomoly angle, satellite height above a mean earth radius, and del 2 beta, the change in total scanned angle of the earth all as a function of time. Plot 1 includes the first 60 minutes from perigee, plot 2 includes the time during which the spacecraft is above are altitude and plot 3 includes the last 60 minutes concluding at perigee. A complete listing of the data plotted, in six second increments, around the entire orbit is available should more precise information be required. Note that in plot 2, the change in scanned earth angle over much of the time results in very

small changes scan-to-scan such that it is believed this systematic change will not result in significant nadir contamination of SAI pixel registration. Since the change is systematic and predictable, it does lend itself to correction by ground data processing.

2. S/C Roll Rate - The error induced in the nadir pulse location by a roll rate on the S/C is strictly analagous to that caused by a change in altitude. If the roll rate is such as to cause the BMHS to view smaller cross sections of the earth, as shown in Figure 4, the earth time and spin period measurements will be in error in the same sense as in the case of increasing altitude discussed above. Roll rates are negligably small throughout the orbit due to the "stiffness" of the DE-A spacecraft.

3. S/C Body Motion

The referenced 30 August memo also addresses the rotation rate and the stability thereof. The details of the operation of the nadir generator, including the constraints imposed by the physical positioning of the body horizon sensor relative to the reference nadir azimuth (the +y axis fo the DE-A spacecraft) result in a modification to the rotation rate requirement as stated to be over a nine second period rather than twelve seconds. This occurs because the nadir generating reference clock is updated one half rotation later rather than the assumed full rotation later. The approach taken to the calculation of worst case angular displacement is correct, however, the resulting peak displacement, assuming a worst case reinforcement of the motion from one eclipse exit to the following is 0.165^{0}. (The calculation resulting in this value is shown in attachment 2). Attachment 4 graphically depicts the variations in true body rate for the disturbances imparted to the spacecraft. The upper curve shows the 41 second oscillation (solid curve) superimposed on the exponential spin rate decay (time constant of 55 seconds) with the worst case AC motion assuming the re-inforcement from one orbit to the next shown as the dotted curve.

The same motion, excluding the exponential decay is shown in the center curve, both for the expected and the worst case reinforced. Finally, the third curve shows the aerodynamic disturbance which builds up and decays in the vicinity of perigee. This disturbance, which has a period equal to the body rotation period is shown for about the 275 km perigee and the 190 km perigee conditions. As this disturbance both appears and disappears well below the 1 R_e altitude noted in the referenced 30 August memo, it is believed that its effects on nadir operation should be neglected.

• Sensor Bias Errors - There are several error sources associated with the BMHS which contribute to the uncertainty of the nadir reference pulse. These sources produce a bias shift in the earth pulse (Figure 2, waveform A) and hence produce a phase shift in the nadir pulse.

1. Threshold Drift - The BMHS on DE is an a.c. coupled sensor which employs independent thresholding of both the leading and trailing earth crossing pulses. The threshold circuits employed have a ±1.5% drift tolerance over time and temperature which results in a worst case drift per edge of ±0.036 degree at 10 rpm in the nadir pulse.

2. Horizon Variation - Variations in both the shape and peak magnitude of the CO_2 horizon (the BMHS is sensitive to radiation in the 16-16 micron, CO_2 spectral interval) radiance profiles will vary the location of the sky-earth and earth-sky threshold points. The radiance (peak magnitude) errors are a function of the rotation rate of the sensor while the shape changes produce shifts which are primarily a function of altitude. The evaluation of these effects is based upon in-house computer simulations.

3. Earth's Oblateness - The bulge in the earth near the equator produces a shift in the earth transition pulse which is a function of the altitude of the S/C and the latitude of the nadir. The induced error is worst when the S/C passes through perigee. This parameter was used to obtain the results shown in Table I.

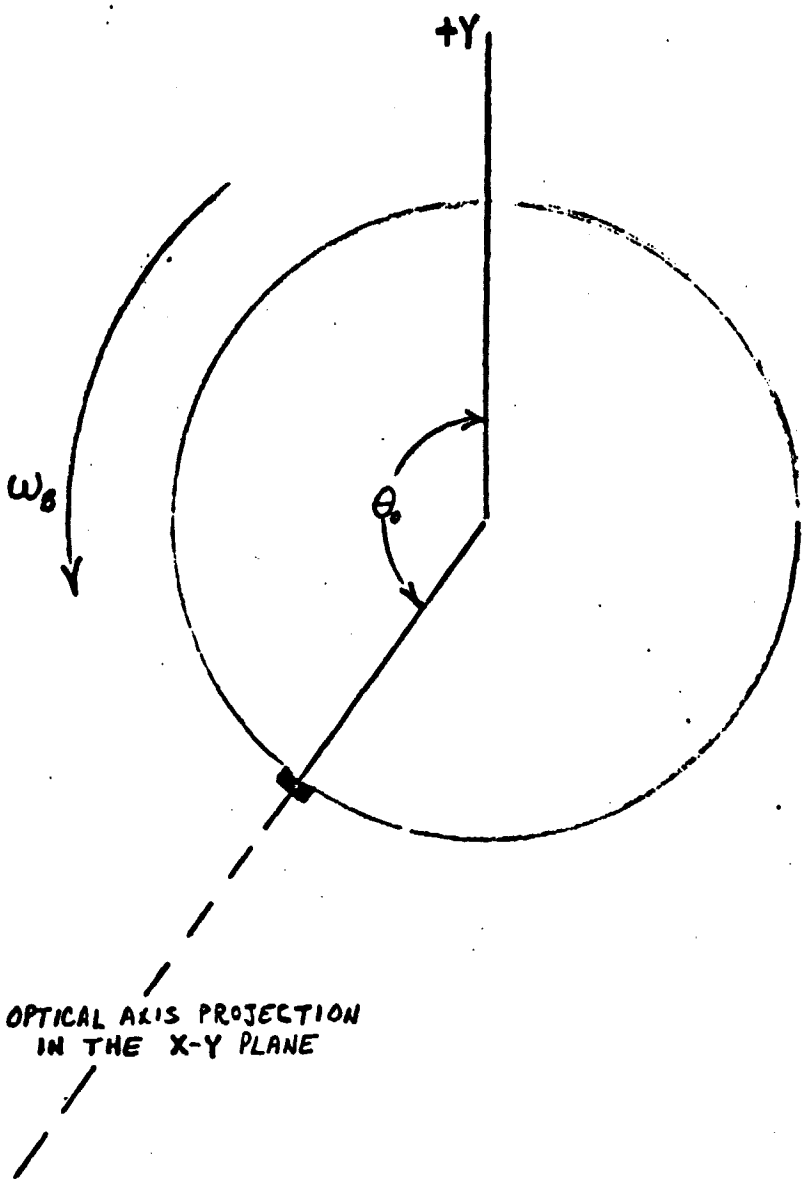
4. Sensor Azimuth Alignment - The azimuthal misalignment of the sensor produces a direct, one-to-one error in the nadir pulse as it represents a shift in the true value of θ_0. The BMHS performance spec specifies that the optical axis of the sensor be aligned to within ±0.1 degree.

5. Dynamic Lag Calibration Uncertainty - Due to the sensor dynamic response time and the earth's limb radiance phenomenon, there is a bias that exists between the earth envelope pulse and the true earth. Current procedures can achieve a calibration to within ±0.2 degree.

REFERENCES:

(1) Nadir Accuracy, Letter dated July 21, 1978 from J. Craven to K. Fellerman.

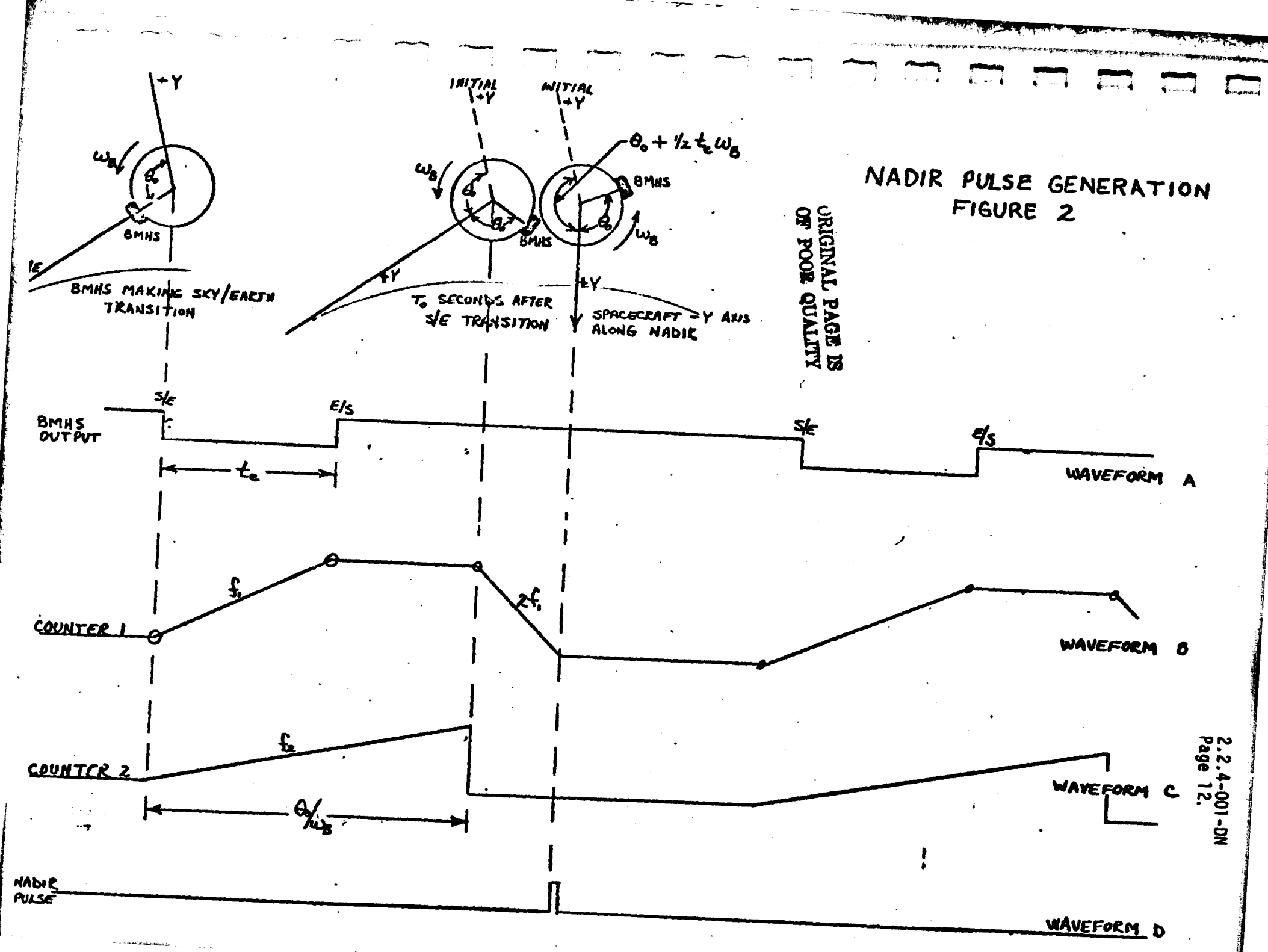
(2) Updated Requirements for Nadir Generator, Letter dated August 30, 1978 from J. Craven to K. Fellerman.



X-Y PLANE PROJECTION OF NADIR GEOMETRY

FIGURE 1

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+Y
ω_B
θ_c
BMHS
I/E
BMHS MAKING SKY/EARTH TRANSITION
INITIAL +Y
INITIAL +Y
$\theta_o + \frac{1}{2} t_e \omega_B$
ω_B
θ_c
BMHS
BMHS
ω_B
+Y
+Y
T_o SECONDS AFTER S/E TRANSITION
SPACECRAFT +Y AXIS ALONG NADIR
NADIR PULSE GENERATION
FIGURE 2
ORIGINAL PAGE IS OF POOR QUALITY
S/E
E/S
BMHS OUTPUT
t_e
S/E
E/S
WAVEFORM A
f_1
$2f_1$
COUNTER 1
WAVEFORM B
f_2
COUNTER 2
θ_c/ω_B
WAVEFORM C
NADIR PULSE
WAVEFORM D
2.2.4-001-DN
Page 12.

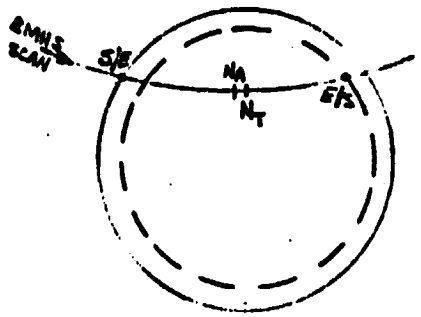


FIGURE 3a
t_e MEASUREMENT

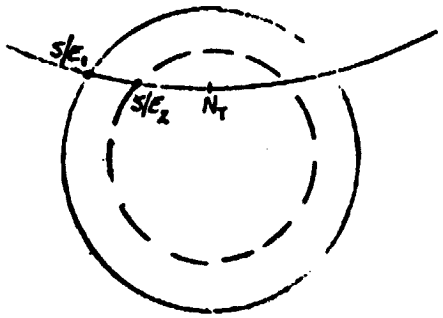


FIGURE 3b
SPIN PERIOD MEASUREMENT

GEOMETRY OF INCREASING ALTITUDE DURING TIME MEASUREMENTS
FIGURE 3

DE-A Noise Estimate

Apogee (Run 508)

S/E Slope = $\frac{.7709 - .7234 V}{.001 \text{ sec}} = .0475$ Volts/msec

Noise ≤ $\frac{V_{peak\text{-}to\text{-}peak}}{12} = \frac{1.445}{12}$ V

$\epsilon_T = \frac{V_N}{\text{S/E Slope}} = 2.54$ msec

$\omega_s = 60°/\text{sec}$

∴ Noise error = $\omega_s \epsilon_T = 0.152°$ per transition

Perigee (Run 551)

S/E Slope = $\frac{.984 - .972}{.005 \text{ sec}} = .054$ Volts/msec

Noise ≤ $\frac{V_{peak\text{-}to\text{-}peak}}{12} = \frac{1.96}{12}$ V

$\epsilon_T = \frac{V_N}{\text{S/E Slope}} = 2.75$ msec

$\omega_s = 60°/\text{sec}$

∴ Noise error = $\omega_s \epsilon_T = 0.164°$ per transition

Calculations will be updated, but expected to remain within 1%

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ATTACHMENT 2

$$\Delta w = K(.003)\,\text{Rev/min} \times \tfrac{1}{60}\,\text{min/sec} \times 360^\circ/\text{Rev} \sin \tfrac{2\pi}{41} t$$

$$= \tfrac{.62}{.4}(.003)\,6 \sin \tfrac{2\pi}{41} t$$

NOTE $\frac{.62}{.4} = K$ is our assessment of the worst-case, in phase reinforcement of the 41 second period sine wave disturbance from one eclipse exit to the second exit.

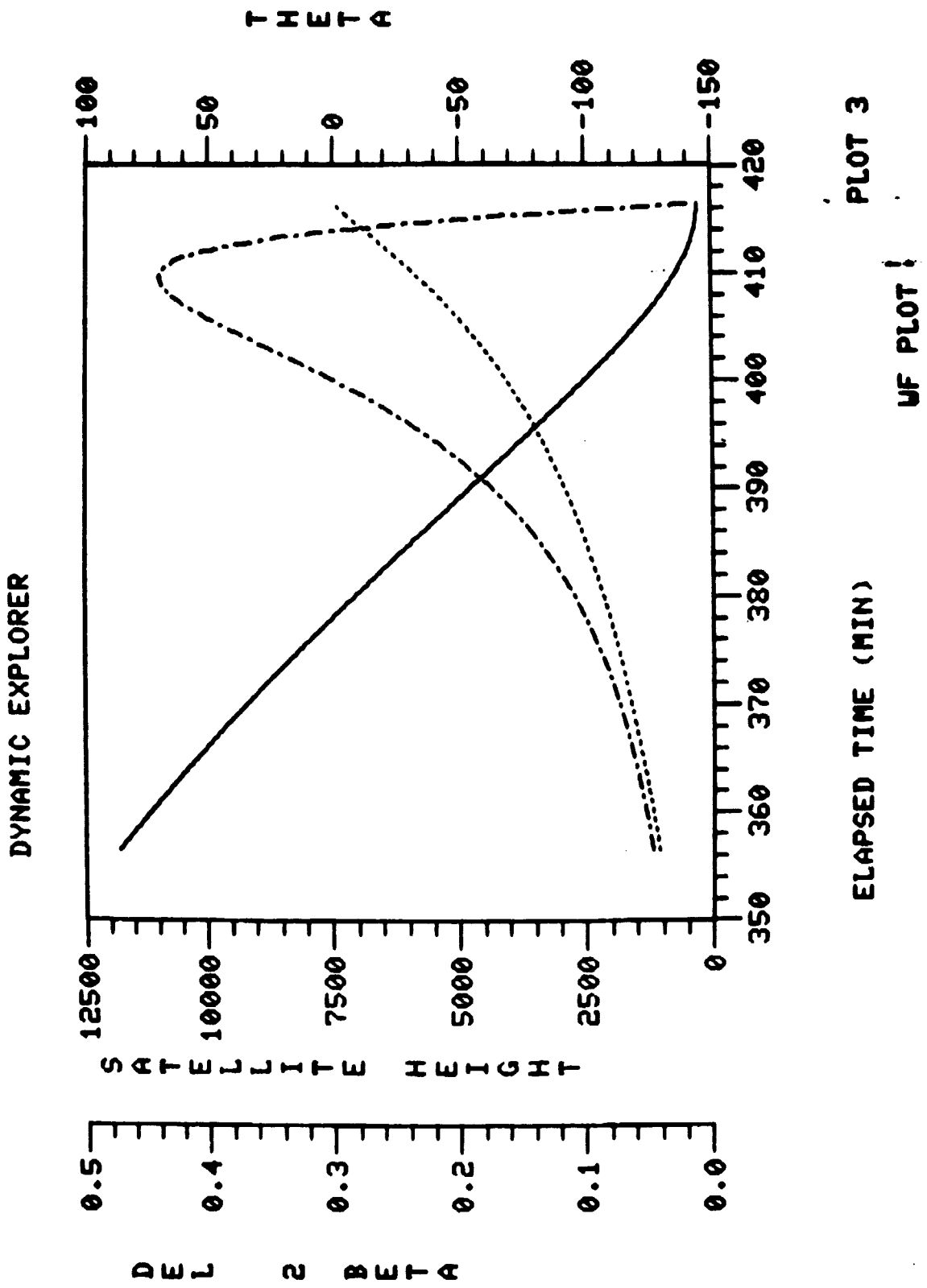
$$\Delta w \equiv \Delta \dot{\theta}, \qquad \Delta \theta = \int \Delta \dot{\theta}\, dt$$

FOR A 6 second interval, the worst case $\Delta\theta$ is twice the magnitude of the change along the cosine curve from the zero crossing to three seconds later.

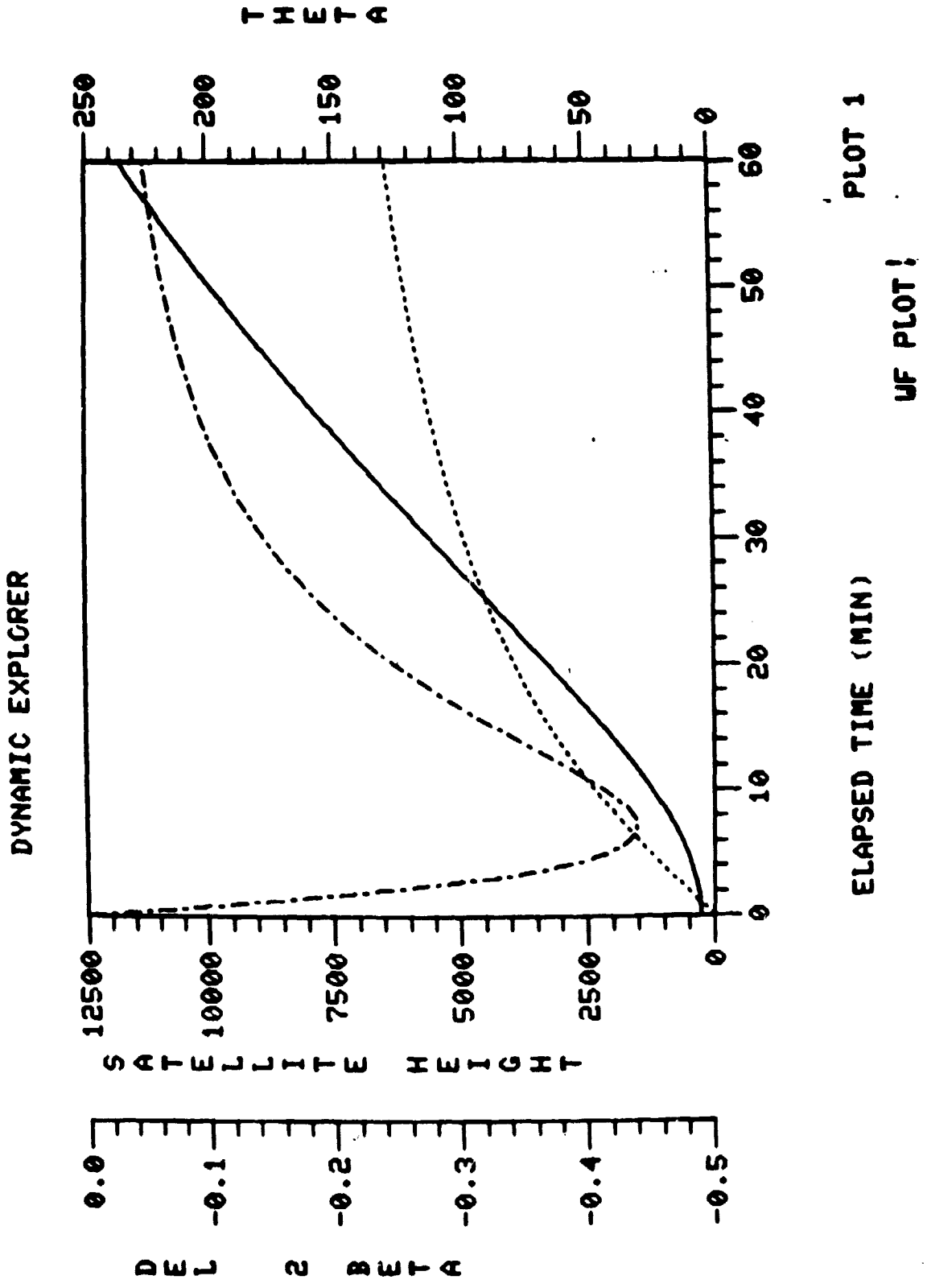
$$\therefore \Delta\theta = 2 \int_{10.25}^{13.25} \tfrac{.62}{.4}(.003)\,6 \sin \tfrac{2\pi}{41} t$$

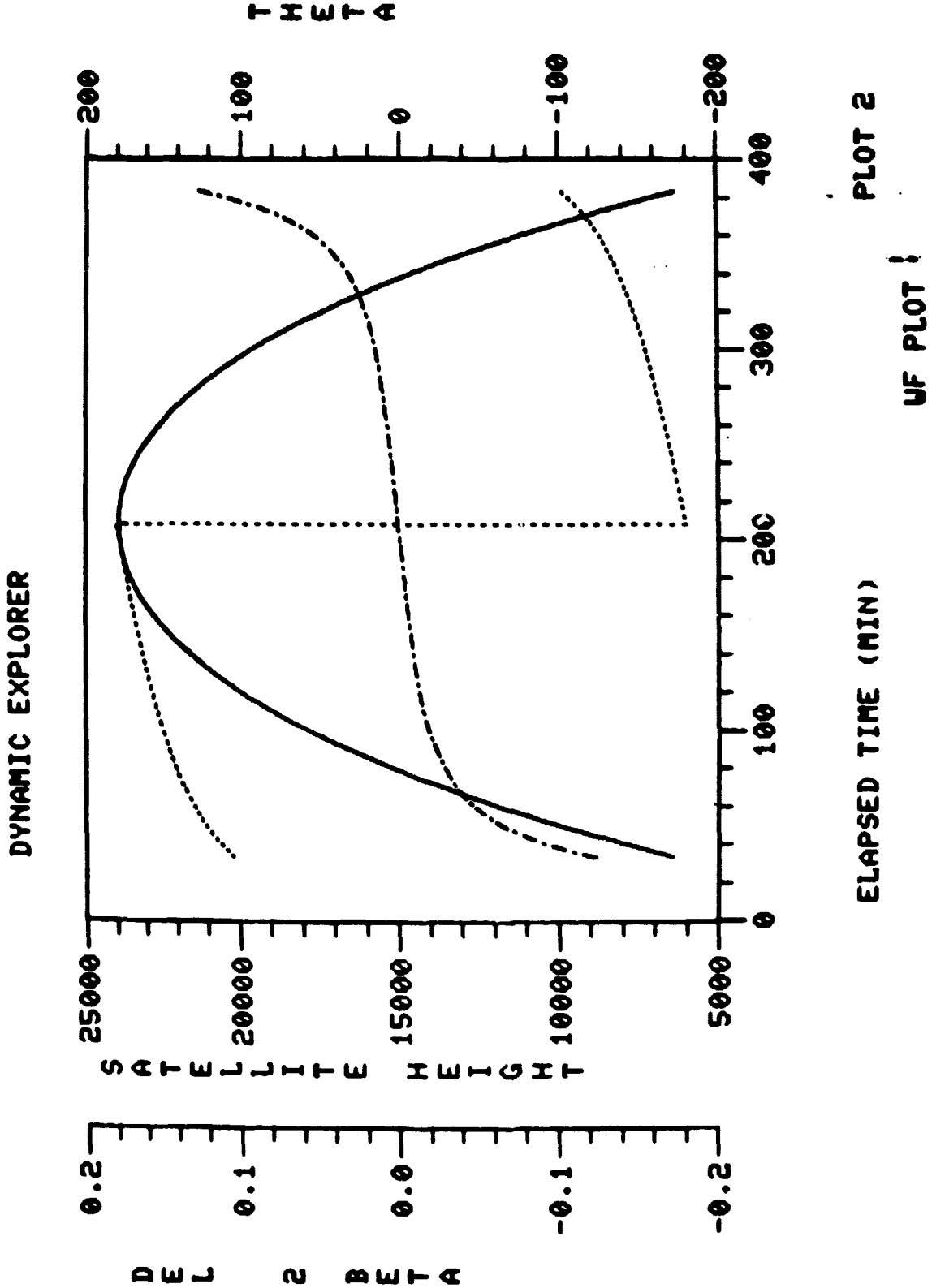
$$= 2 \frac{\left(\frac{.62}{.4}\right)(.003)6}{2\pi/41} \sin \tfrac{2\pi}{41} t \Big|_{10.25}^{13.25} = .165^\circ$$

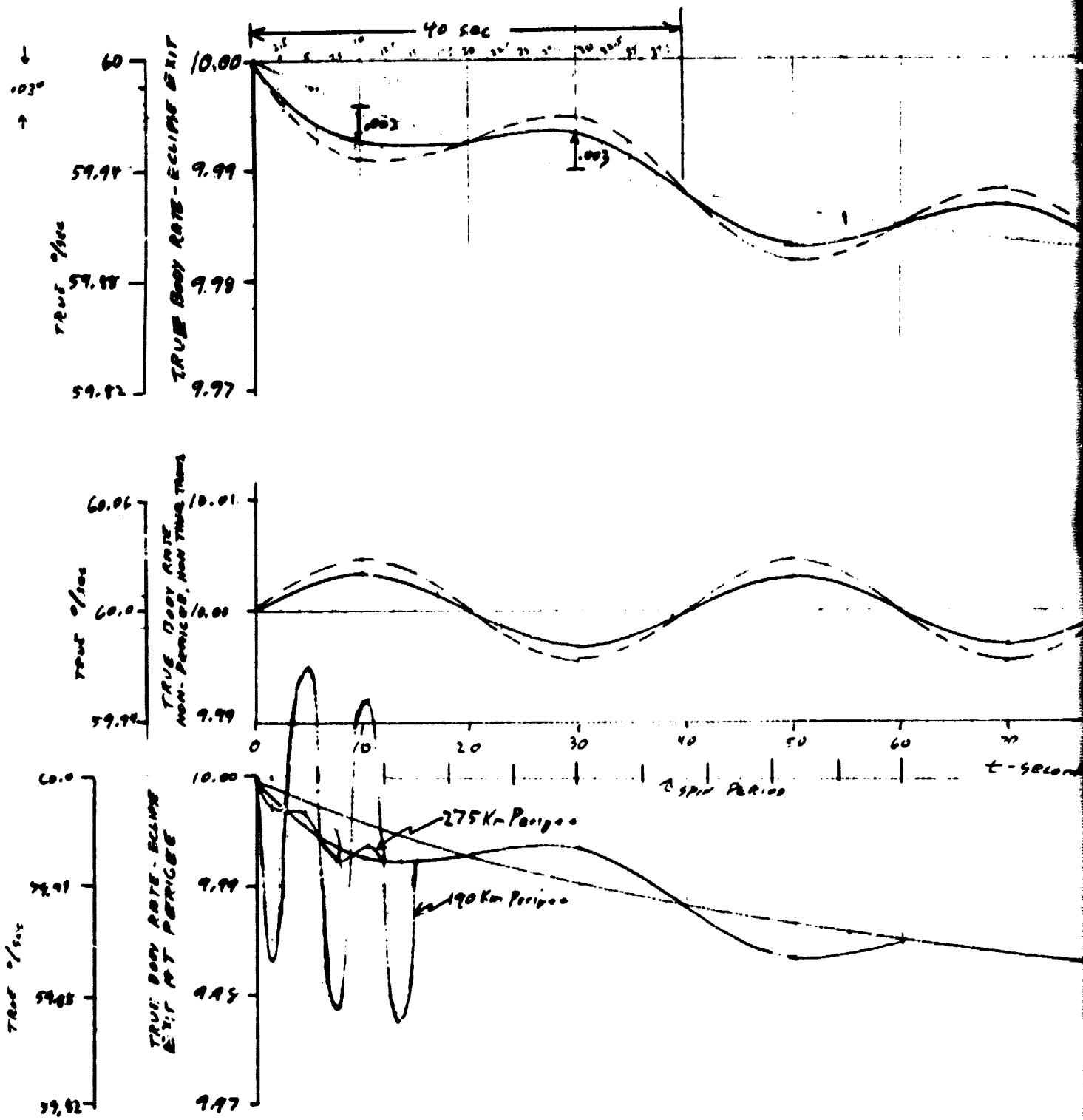
ATTACHMENT 3



ATTACHMENT 3
(continued)

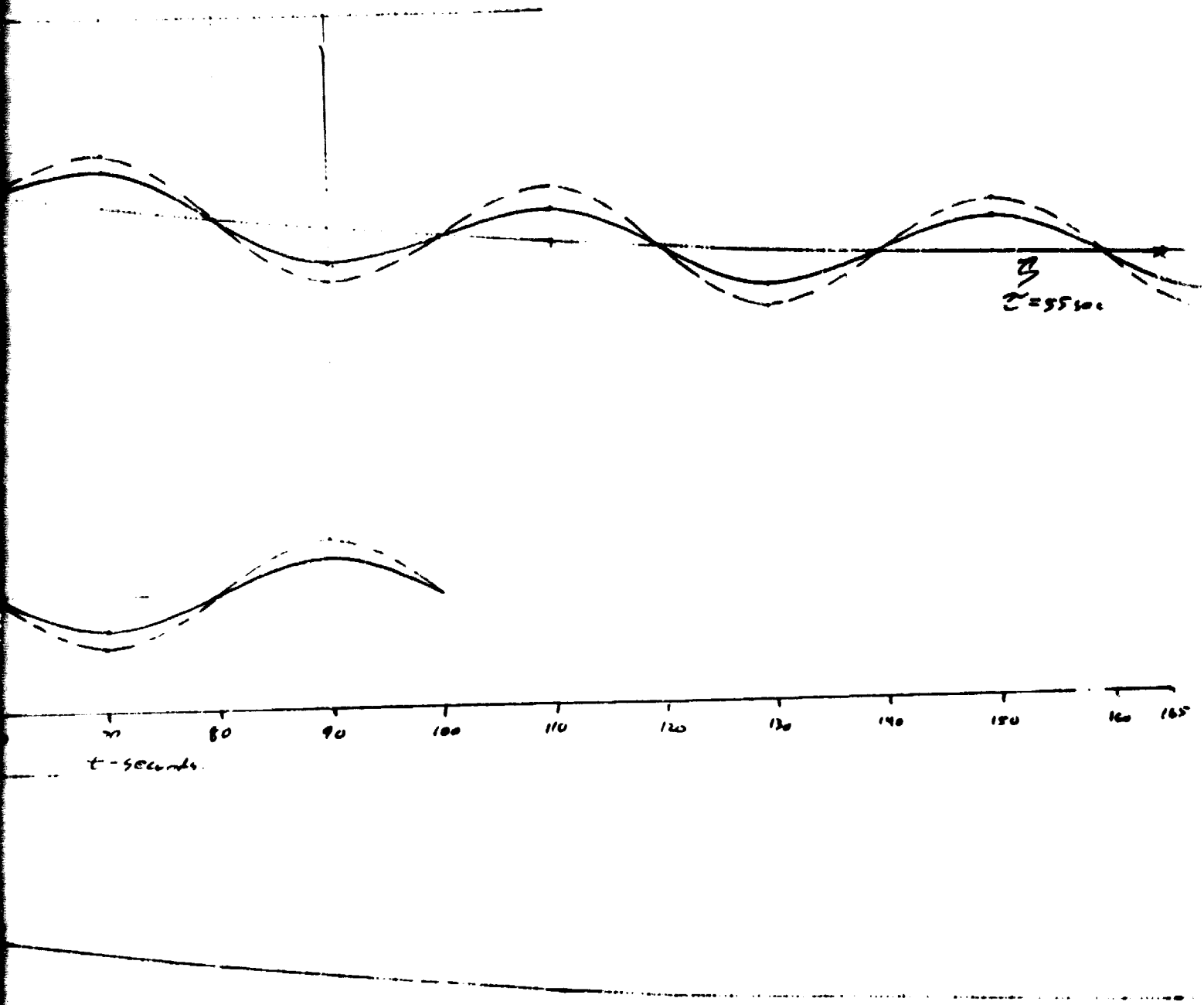



THETA
200
100
0
-100
-200
DYNAMIC EXPLORER
PLOT 2
UF PLOT 1
ELAPSED TIME (MIN)
0
100
200
300
400
SATELLITE HEIGHT
5000
10000
15000
20000
25000
DEL 2 BETA
0.2
0.1
0.0
-0.1
-0.2



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FOLDOUT FRAME



FOLDOUT FRAME 2

ATTACHMENT 4

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 2.2.4-003-DN

Title

Spacecraft Launch Configuration and Initialization

Written by: W. V. Fuldner	Date October 16, 1978
Approved by:	Date
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

Letter	Description	Date	Author

1.0 INTRODUCTION

The launch scenario for the stacked spacecraft and the subsequent orientation and initialization maneuvers take maximum advantage of the capabilities of the system design while minimizing the interfaces with the launch vehicle. The flow of activities from liftoff until the completion of the 30-day initialization maneuvers is shown in Figure 1.

2.0 DEPLOYMENT OF DE-B

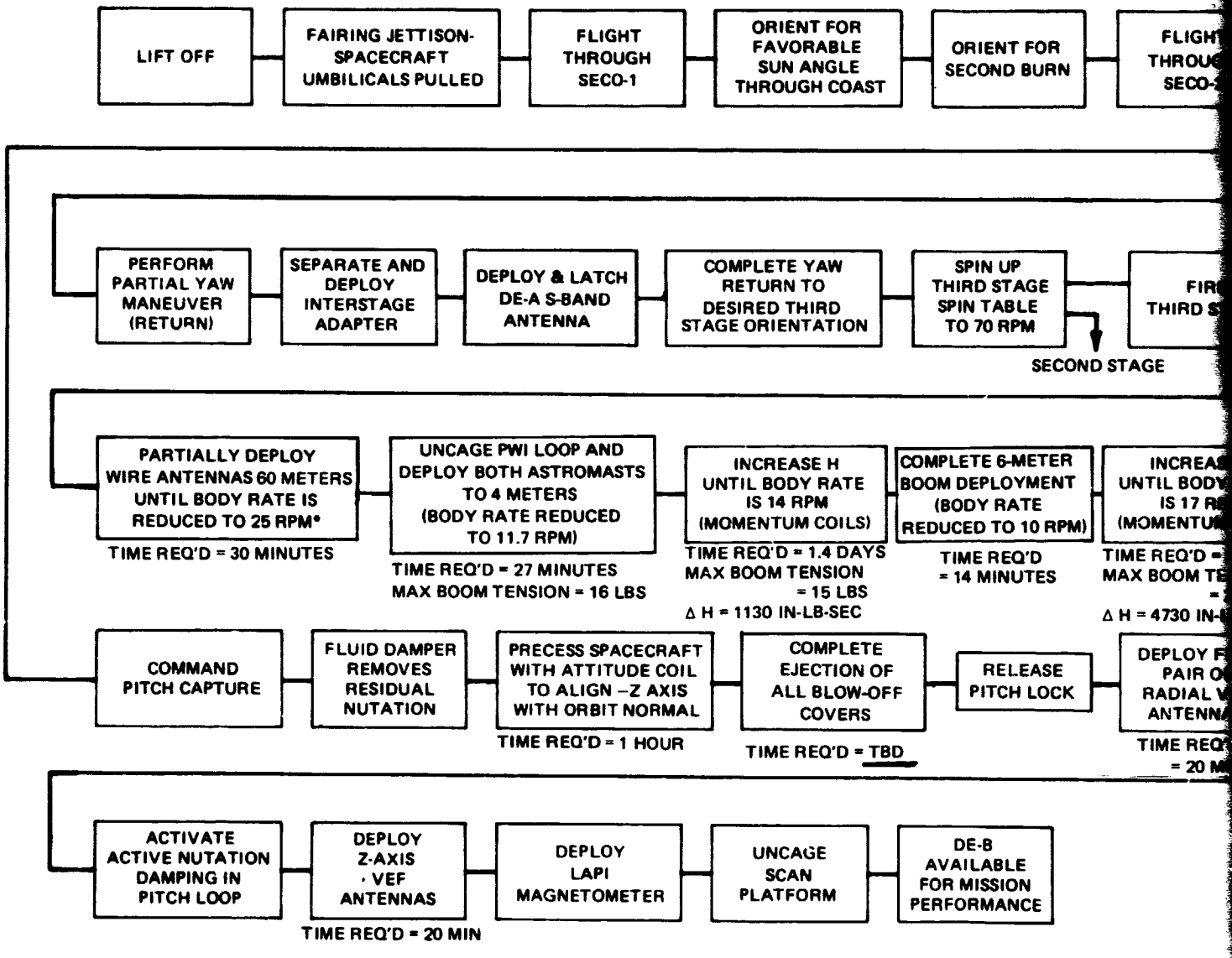
The assembled stack, third stage, and second stage may require orientation to achieve a favorable sun angle during the coast phase between the first and second burns of the second stage. This is a departure from the normal Delta procedure of immediately orienting to the second burn orientation after SECO-1. Such maneuvering may be required as the forward facing end of the DE-B Spacecraft on the top of the stack is the same end which contains the thermal louvers. The thermal design of DE-B will not tolerate extended periods of direct solar input to this surface. The maneuvering required is an analysis task to be performed in conjunction with the Delta Office during the course of the program.

2.1 Yaw Orientation

Subsequent to the second burn of the second stage, the complete stack, under the control of the second stage guidance system, executes a yaw maneuver in excess of 75 degrees from the orbit plane, bringing the -Z axis to within 15 degrees of the positive orbit normal. This maneuver serves to establish the DE-B Spacecraft in nearly the desired orientation for the mission. The actual angle selected will be defined as a result of an analysis performed in conjunction with the Delta Office under two primary constraints, namely:

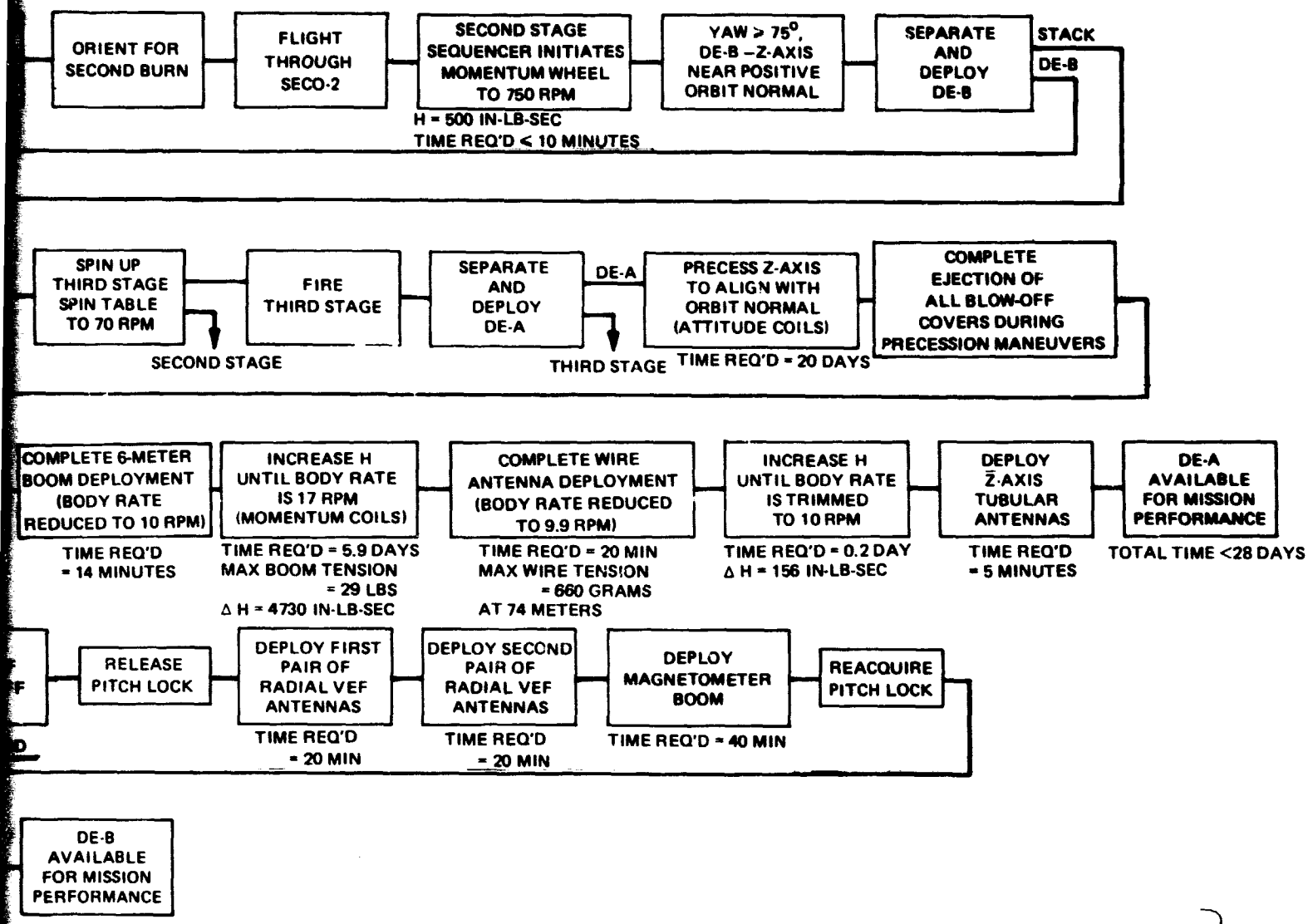
1. The spacecraft must be oriented sufficiently close to the mission mode to permit the wheel horizon sensors to scan the earth during the entire orbit.

2. A satisfactory forward velocity component can be maintained resulting from the separation spring action to achieve adequate and safe separation spacing between the DE-B spacecraft and the third stage at the time of third stage ignition.



*MAXIMUM TENSION OF 1900 GRAMS AT 38 METERS DURING THIS OPERATION.
MINIMUM TENSION >17 GRAMS.

FOLDOUT FRAME



FOLDOUT FRAME 2

Figure 1. Launch, Acquisition, and Initialization Sequence

2.2 DE-B Angular Momentum Establishment

In the interval between SECO-2 and the completion of the 75 degree yaw maneuver, the momentum wheel will be turned on in response to an electrical interface with the second stage sequencer. Reacting against the attitude control system of the second stage, the wheel will be rotated to 750 rpm, resulting in the establishment of approximately 500 in-lb-sec of momentum within the momentum wheel. Thus at separation, the DE-B spacecraft will possess the nominal system momentum required for the mission.

2.3 Initialization of DE-B

Subsequent to deployment, the 30-day initialization period incorporates the following activities: The momentum wheel is commanded into pitch capture orienting the body of the spacecraft at 1 rpo. The remainder of the precession maneuver is completed using the attitude control torquers, aligning the -Z axis with the positive orbit normal. The system momentum is then "trimmed" to the nominal 500 in-lb-sec using the momentum torquer. Note that on the DE-B spacecraft, momentum torquing must be performed while in the 1-rpo state, as there is no sensor available to define commutation conditions as is done on the DE-A via the BHS.

During the time that the precession maneuver is completed and the momentum is augmented to the nominal system value, the spacecraft outgassing is completed and all "blow off" covers are ejected. All such ordnance-activated deployables will be ejected prior to the start of boom deployment. Also during this time, residual nutation will be removed by means of the fluid damper.

During the following deployments, the pitch control subsystem is operated in the "open loop" mode to avoid the potential for dynamic interactions between the erectables and the momentum wheel. One pair of the VEF 11-meter antennas in the X-Y plane is then deployed, followed by the second pair of X-Y plane VEF antennas. Next, the magnetometer boom is deployed. Completion of the deployment of this mechanism generates the inertial cross product required by the system to perform active nutation damping. Thus, upon completion of the deployment, the pitch control electronics are commanded to initiate active nutation damping.

The Z-axis 11-meter VEF antennas are deployed, followed by the erection of the LAPI magnetometer mast and the uncaging of the scan platform. Upon completion, the DE-B spacecraft is in the fully operational mission state.

2.4 Preparation for Third Stage Burn

Referring to Figure 1, subsequent to the deployment of the DE-B spacecraft, a return yaw maneuver is initiated on the remainder of the stack. This maneuver is interrupted to permit the deployment of the interstage adapter. Upon completion, maneuvering is re-initiated until the assembly is in the desired orientation for the third stage burn. The deployment of the 1828 adapter (interstage adapter) is sensed by the DE-A C&DH system to initiate erection of the DE-A S-band antenna. The third stage spin table is activated, achieving the planned 70-rpm rate. This rate has been selected to optimize the amount of time required, within the allowable range of 70 to 120 rpm to precess the spacecraft to the mission orientation, and also to optimize the accelerations imparted to the deployed antenna while still achieving the science driven obrit dispersions.

2.5 DE-A Precession Constraints

The primary concern of quickly accomplishing the precession maneuver is to minimize the time during which the spacecraft is oriented unfavorably for thermal system performance. Until the spin axis of DE-A is nearly aligned with the orbit normal, there are significant periods of time in each orbit where the thermal louvers on the anti-sun end of the spacecraft are not viewing the cold space sink but are viewing the earth instead. The system then has reduced capability to expel heat. Similarly, the BHS will not view the earth for significant portions of the obrit, and, in like manner, the pattern of the S-band antenna will not be favorable for portions of the orbit.

2.6 DE-A S-Band Antenna Considerations

At apogee and at perigee, the link performance will be as in the link tables (see 3.5.2-001-DN "DE-A and DE-B Link Analysis") regardless of the Z-axis orientation. When not at apogee or perigee, link performance will be degraded by an amount which depends on the orientation of the Z-axis. The worst-case will occur when the Z-axis lies in the orbit plane. In this case, approximately 75% of the orbit period will be available for commanding, 60% for ranging, and 50% for HEW telemetry. The contact time will be centered near apogee. There also will be a brief contact interval (approximately 2 minutes) near perigee.

As the precession maneuver moves the spin axis from the orbit plane to the operational orientation, the coverage capability increases until the operational capability as shown in the proposal is achieved.

2.7 Initialization of the DE-A Spacecraft

As noted above, the first maneuver performed subsequent to the third stage separation is the precession to align the spin axis to the orbit normal. While the total time from separation to mission configuration achievement is approximately the same for the total range of third stage spin rates, the percentages of this time allocated to precession and to momentum adjustment vary greatly. As was the case in DE-B, the outgassing of the spacecraft and the ejection of all blow-off covers will be achieved prior to the initiation of any deployables other than the S-band antenna.

The wire antennas are partially deployed (approximately 60 meters), thus reducing the body spin rate. The body rate is then approximately 25 rpm.

The PWI loop antenna is then uncaged, and the two instrument booms are partially deployed to approximately 4 meters resulting in a reduction in the body spin rate to approximately 11.7 rpm The body rate is increased to 14 rpm by the addition of system momentum. Note that the addition of momentum to the system requires commutation of the momentum coils under control of the BHS which in turn, requires the spin axis to be aligned closely to the orbit normal. The 6 meter instrument booms are then deployed to their full length, followed by another augmentation of system momentum until the body rate is approximately 17 rpm. The deployment of the wire antennas to their full 100-meter length is then completed, with the body rate at the completion approximately 9.9 rpm. The momentum is then trimmed to the desired 10 rpm. The strategy of targeting the spin rate as slightly under 10 rpm at the completion of the wire antenna deployment is based on minimizing the amount of time taken in adding momentum to the system throughout the process. Upon completion of this maneuver, the 3-meter Z-axis antennas are deployed, and the DE-A spacecraft is in the operational mission condition. Assuming nominal unregulated bus voltages, which are the power source for the magnetic torquers, the total torquing and deployment tasks will be accomplished within the 30-day initialization period as indicated by the time allocations in Figure 1.

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No.
DYNAMICS EXPLORER	2.3.3-023-DN

Title: CONSIDERATIONS AFFECTING THE IMPLEMENTATION OF SOLAR CELL BYPASS DIODES AND RESULTING SOLAR ARRAY OUTPUT NOISE

Written by: W. Fuldner	Date May 15, 1978
Approved by: R de Bortoli	Date
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

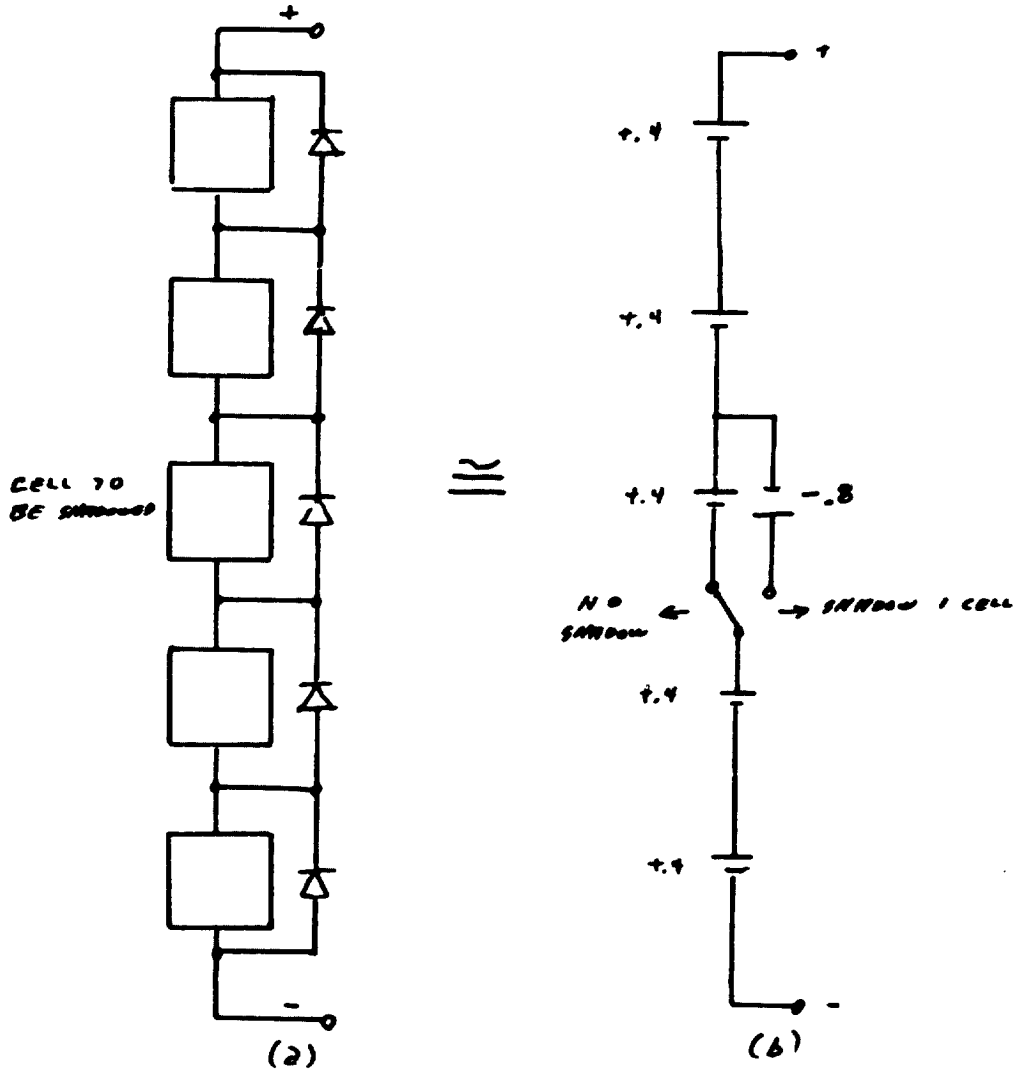
Letter	Description	Date	Author

INTRODUCTION

This design note addresses the effects on solar array output voltage and current resulting from the addition of bypass diodes to the solar cells of the solar array. Included in the evaluation presented are some alternative considerations to solar cell layouts and the complexities involved for the two different solar arrays for DE-A and DE-B. Also addressed is the proposed implementation technique for the installation of the diodes to minimize the impact on present solar array fabrication techniques.

BACKGROUND

To assess the performance of the solar array and the need for bypass diodes, the following discussion is presented. Consider a series connected string of five solar cells as shown in Figure 1-a. As shown, each cell has a bypass diode in parallel with the cell. In the event one of the series cells is shadowed, the current generated by the remaining series cells can continue to flow via the diode of the shadowed cell, thus permitting continued energy generation in the presence of localized shadows to some cells in the string. While permitting the continued generation of current under shadowed conditions, there is a resulting decrease in the output voltage of the string shown schematically in Figure 1-b. In the unshadowed condition the output voltage is 5 x 0.4 volts/cell = 2.0 volts. When the shadow occurs, there is one less cell generating voltage and an additional drop of approximately 0.8 volts across the conducting diode. Thus, for every series cell that is shadowed, assuming a diode around each cell, the loss in output voltage is 0.4 +0.8 = 1.2 volts. For the five cell series string of Figure 1, with one cell shadowed, the output reduces to 0.8 volts. Consider four series strings of "n" series cells, which are in turn connected in parallel to form an array as indicated in Figure 2. The solid line curves represent the normal (unshadowed) performance of each string and of the composite array. If a cell in string one is shadowed, the curve shape is the same except for the dotted portion as shown for string one, and its resulting impact to the composite array. In Figure 2, the load line of the shunt limiter is superimposed, and is shown intersecting the maximum power point on the solar array, the normal design practice when shadowing is not considered. With the effects of shadowing, however, as can be seen in Figure 2, the voltage reductions experienced when bypass diodes are employed result in significant movements of the operating point of the array output voltage (addressed below under discussion). For this reason, overdesign of the solar array can be considered by adding additional series cells to each string and intentionally establishing the shunt limiter at a non-optimum power point on the array curve. By so doing, the area of variation of the curve due to shadowing of any of the individual string cells is moved above the normal operating point on the array curve. This technique results in decreased array efficiency in that more solar cells are being flown than ordinarily required without shadowing, and adds additional constraints to the geometry considerations of the physical mounting of the cells to the spacecraft.



NO SHADOW

$V_{OUT} = 5(.4\,v) = 2.0\,v$

SHADOW 1 CELL

$V_{OUT} = (5-1)(.4) + (-.8) = +.8\,v$

FIG 1 - BASIC CELL SHADOWING CONSIDERATIONS.

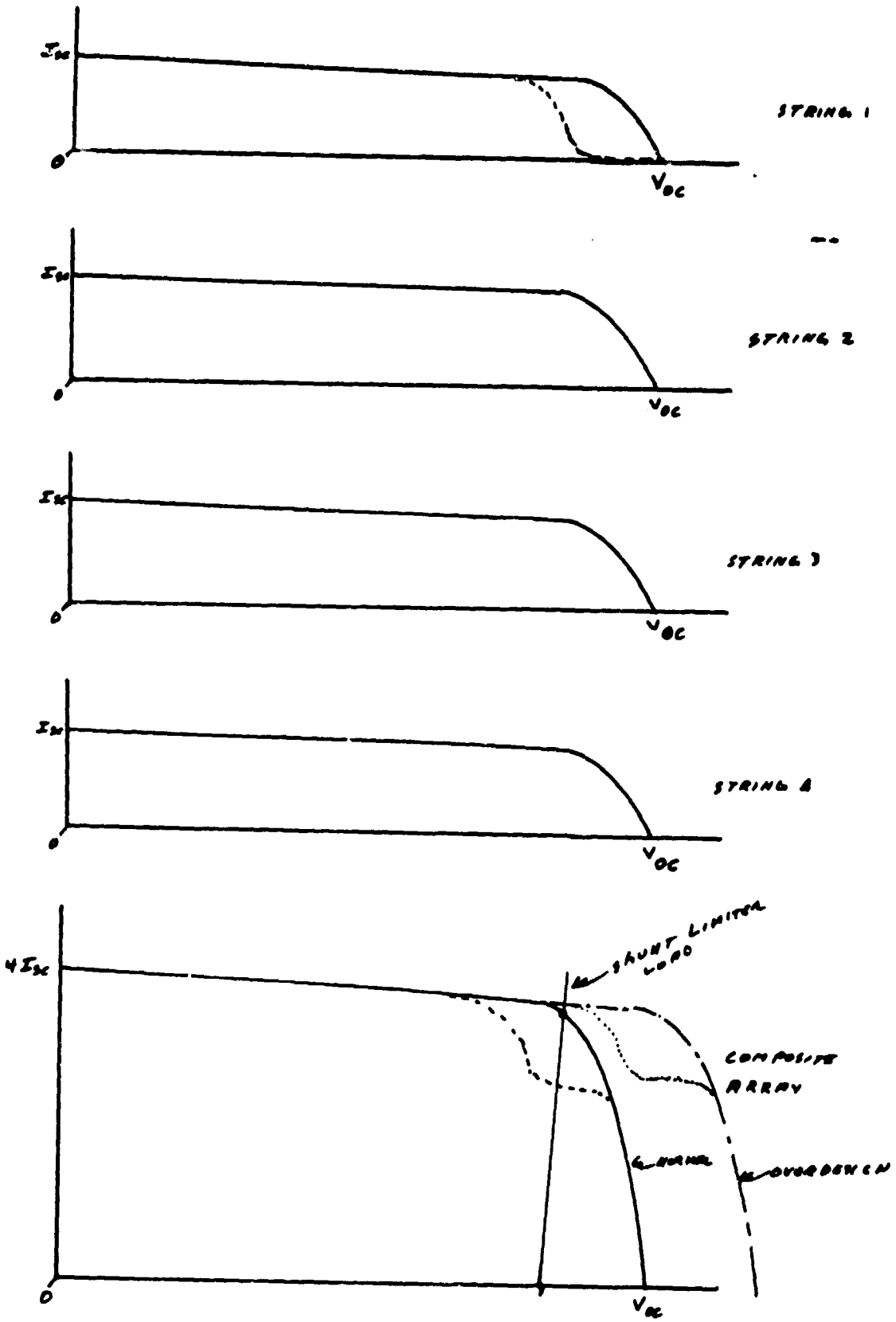

I_{SC}
0
V_{OC}
STRING 1
STRING 2
STRING 3
STRING 4
$4I_{SC}$
SHUNT LIMITER LOAD
COMPOSITE ARRAY
CHANNEL
OVERDRIVEN

FIG 2

DISCUSSION

Considering now the DE solar array, the basic operating curve for which is shown in Figure 3, with V_{oc1} the open circuit voltage of the normal array and I_{sc} the instantaneous short circuit current for the existing sun angle and hat orientation dictating how many of the available series strings are illuminated. If the spacecraft load requires a total current out of the solar array of I_{L1}, the shunt limiter is actuated and the excess current from the array $I_{L2}-I_{L1}$, is diverted to the shunt limiter, and the operating point of the solar array is at node "A". If a shadow is now experienced, leading to the dotted performance curve of the array, the operating point on the array moves to node "D", with a change in current in the shunt limiter of $I_{L2}-I_{L3}$. Note that this will result in a rapid change in shunt current but relatively little variation in solar array voltage. Conversely, consider the condition when the spacecraft-demanded load is approximately I_{L2} and a shadow occurs. Under the conditions prior to shadowing, the operating point is still node "A" but under these conditions, no current is flowing in the shunt. When the shadow occurs, the array seeks a new operating point, namely node "C" where it can again supply the demanded current I_{L2}, and a voltage variation of $V_{sh}-V_c$ is experienced.

If the geometry of the solar array precludes a solar cell layout which, in conjunction with the variations in array operating temperatures, precludes the addition of sufficient cells to "overdesign" the array (curve of V_{oc2} of Figure 3) such that the shadow variations occur above the shunt limiter operating point, two alternatives are available.

1. To minimize the voltage noise for instrument operation when shadowing will occur, operate the system either with a light enough load so that the voltage variations are minimized by having the shadow-induced operating changes not be significant enough to exit from shunt limiter operation; or, alternately,

2. Load the system sufficiently to get to a sufficiently low operating point on the array curve to be below shadow voltage variations.

If the prime noise concern is the current variations in the shunt limiter, then the first solution, even with the bypass diodes is less favorable than the second.

DE-A Side Panel Array Layout

Present predictions of operating temperatures for the side panels of the DE-A solar array indicate a requirement for 86 series solar cells in each string. As shown in Figure 4, the proposed solar cell array layout utilizes, for the blank panels (no cutouts), strings of cells which are three parallel cells by 86 cells long. This allows for no additional cells to be dedicated to compenstation for diode voltage drops while retaining a design that permits discrete cell circuits to be dedicated to a single panel. Also shown in the Figure is the path to be followed by the return wire for the cells of the

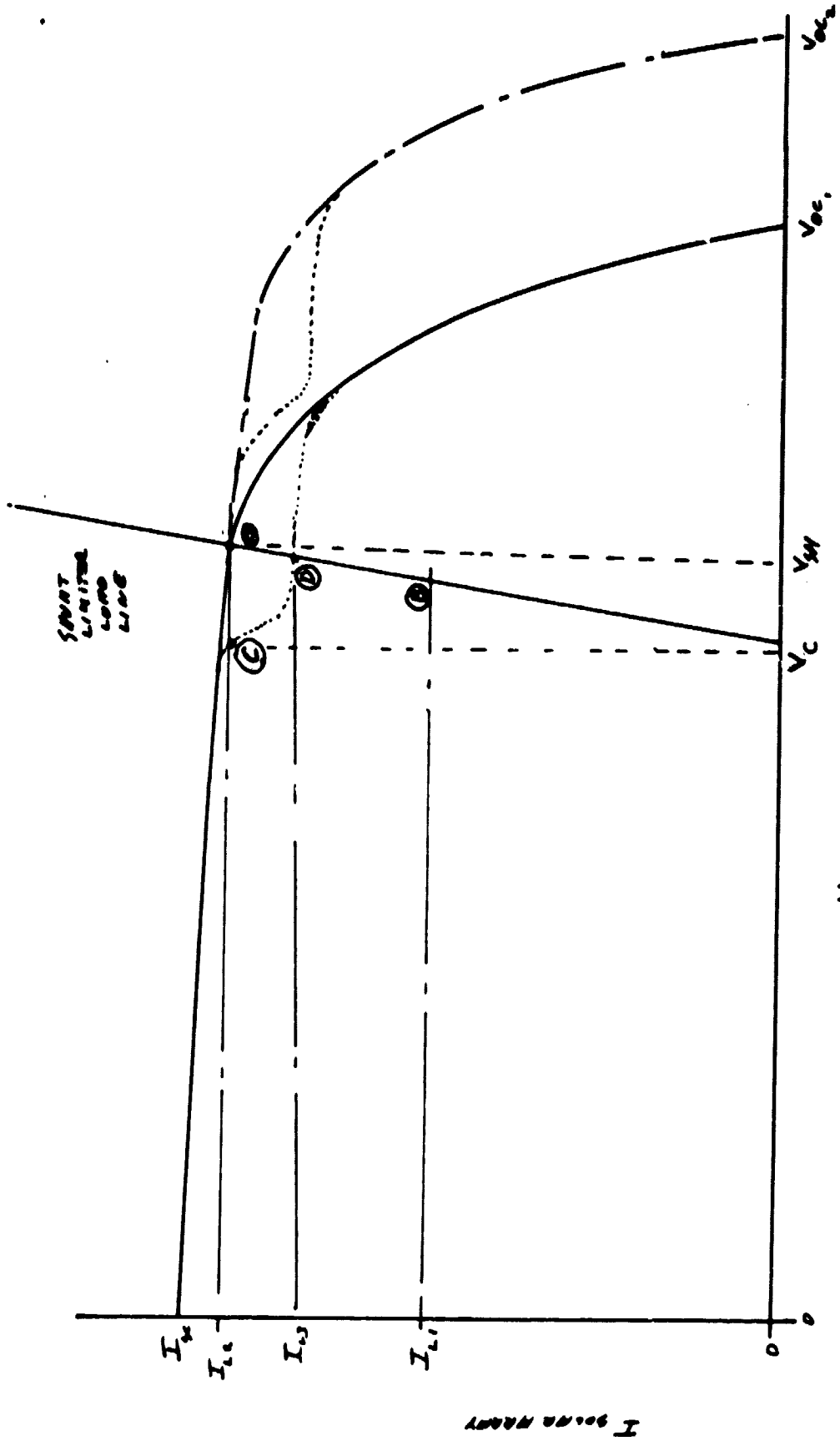
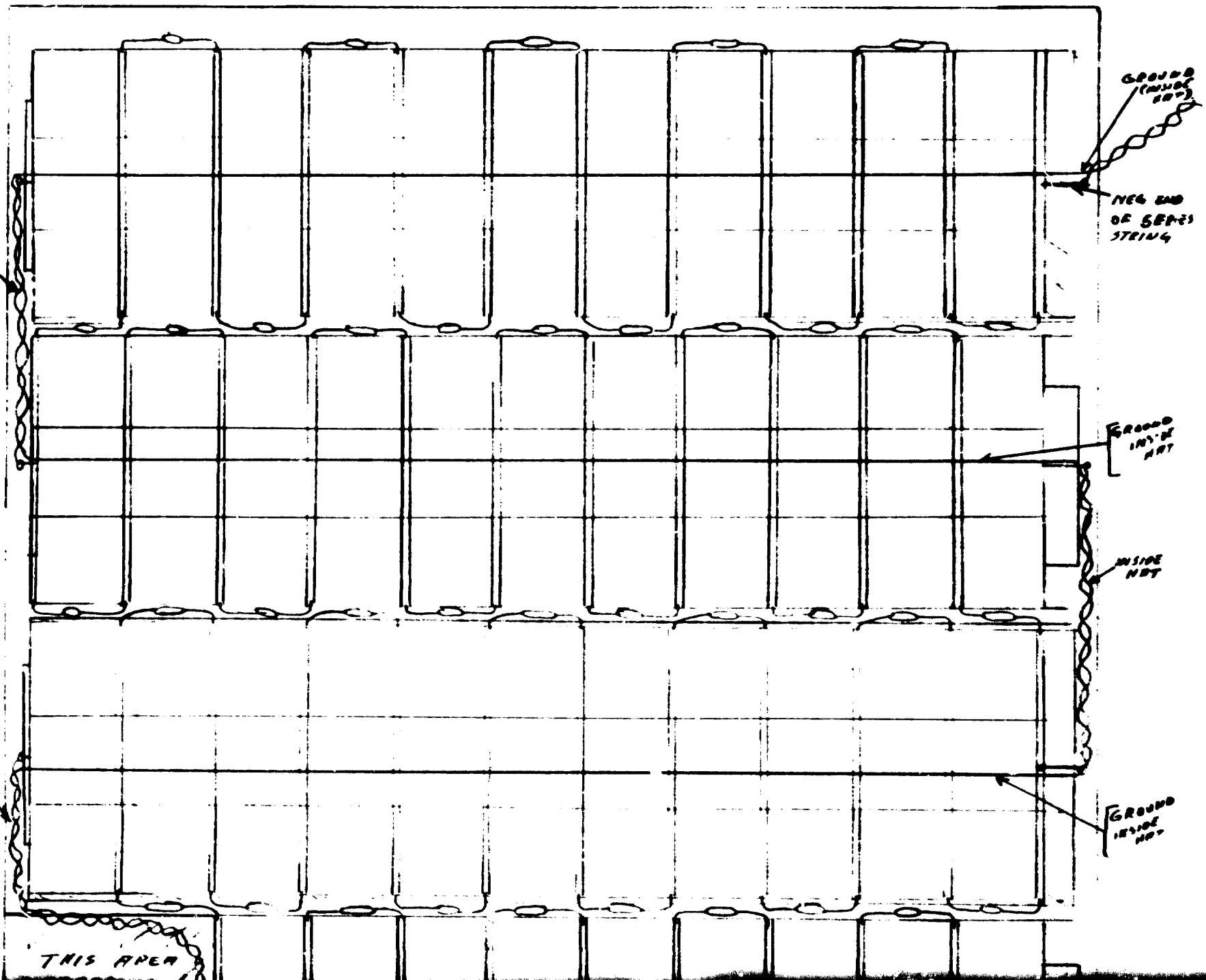
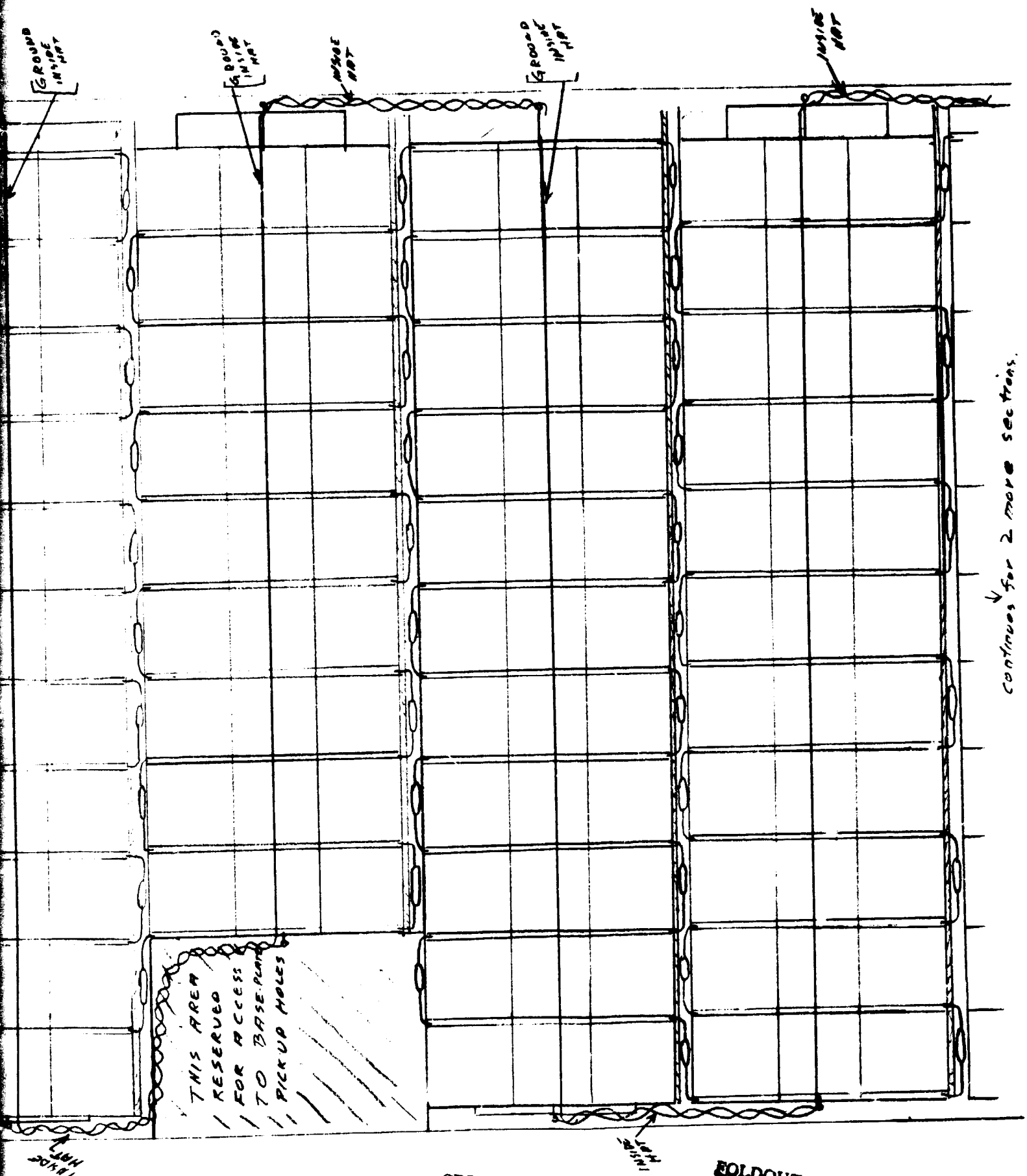


FIG 3

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FIG 4 DE-M SIDE PANEL LAYOUTS





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FOLDOUT FRAME 2

particular string. If an aperture is required in the panel for an instrument, the same technique will be used except that the number of parallel cells will be reduced from 3 to 2 or from 3 to 1 depending on the size of the aperture.

DE-B Side Panel Layout

The same approach will be taken in the layout of the side panels of the DE-B solar array except that the only single parallel cell or at most two parallel cells will comprise the strings. This results from the expected operating temperature of the DE-B despun spacecraft solar array being warmer than that of DE-A and therefore requiring more series cells in the array to achieve the required operating voltage. With a thermally required 117 series cells in the DE-B array, and adding four additional cells for shadow compensation, the layout technique for DE-B will be the same as that for DE-A.

An assessment of this layout of the side solar arrays for both hats has indicated that the A array will consist of the following combination of strings of 86 series cells:

Panels with three parallel cells	20
Panels with two parallel cells	12
Panels of single cells	3

and DE-B side array will consist of the following combination of 121 series cells:

Panels of two parallel cells	28
Panels of single cells	5

Noise Signature on Solar Arrays

As was noted in the background discussion above, the addition of the bypass diodes will not eliminate voltage and/or current variations on the solar array resulting from shadowing unless "overdesign" of the array is included to move the operating point of the array/shunt limiter to below the worst-case voltage notch resulting from operation of the diodes. With the limitations imposed on the layout of the DE-B side array permitting no more than two parallel cells in any series string, the ability exists to increase the number of series cells from the required 117 to 129, thereby adding 12 series "overdesign" cells and eliminating or greatly reducing the voltage noise and shunt current noise described above.

For the DE-A side array, the 86 series cell requirement allows for no "overdesign" cells and thus would permit noise, as noted above, to exist if appropriate load programming cannot overcome the problem. In the event that the worst-case operating point is encountered for voltage noise (solar array operating just at the threshold of shunt limiting) and a maximum of four cells in a string are shadowed, then the worst-case shadow induced voltage variation would be (refer to Figure 1):

$$V_{out}\Big|_{\text{no shadow}} = (82)(.46045) - 39.5V$$

$$-V_{out}\Big|_{\text{shadow}} = (86-4)(0.46045) + (4)(-0.8) = 34.56V$$

$$\text{Voltage Variation} = 4.94V$$

NOTE: In this calculation, the precise cell voltage of 0.46045V is used corresponding to the predicted side array temperature for DE-A as opposed to the .4V / cell of the simplified example in Figure 1.

Thus, with the array threshold at 39.5 volts (topmost solar cell string voltage), this shadow ripple would result in a peak voltage excursion of 4.94 volts. Initially, such a voltage ripple is judged to be unacceptable. However, consideration of the frequency of such a ripple may place it in a location in the spectrum where it is not of significance. The side array is rotating at 10 rpm; thus, the rate that any string of cells can experience shadowing is approximated by 35 strings per hat divided by half the spin period; 3 seconds. Half the spin period is considered as the shadow, in worst-case, must initiate and terminate only during the half of the rotation in which the array is illuminated. Thus, the maximum frequency of the ripple should have an upper bound of no more than 12 Hz. If this is out of the region of spectral interest, it is conceivable that such a shadow-generated noise is acceptable. Note also that the transition from illumination to shadow and back to illumination will be relatively slow as opposed to instantaneous step changes, thereby minimizing the spectral harmonic content of the ripple voltage.

Alternately, if the operating point of the system is such that significant shunt current is flowing (see background discussion), the voltage ripple may not exist, but current ripple in the shunt may vary at the same rate as noted above. Under this condition, assuming the shadowed cells are in parallel independent single cell strings (worst-case) then the current ripple could be 4 x 110 ma/cell/hat =0.88 amps peak variation.

If the selected shunt dissipator design approach, and the return path for the array current approach is satisfactory, then the magnetic noise variations resulting at the approximate 12 Hz variation may not be unaccpetable.

CONCLUSIONS

Initial assessment of solar array performance, including the effects of bypass diodes for shadowing indicates that the DE-A array has the potential for significant noise amplitudes in either current or voltage variation in the low frequency regime (less than 12 Hz). If the existence of the noise in this region does not pose a significant noise problem, it is recommended that the array design be so implemented. The DE-B side array can be "overdesigned" to move the operating point to a location which will preclude the existence of significant noise. Should the DE-A noise signature be unacceptable, then alternate array layouts, which require individual strings of the array to be physically housed on more than one side panel must be considered, along with the additional complexities in fabrication, fixturing and testing of the array panels.

DYNAMICS EXPLORER

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Originating Project or Group	Note No.
DYNAMICS EXPLORER	2.4.1-004-DN

Title

DYNAMICS EXPLORER WEIGHT REPORT DE-A

Written by: K. R. Johnson	Date 1 November 1977
Approved by:	Date
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

Letter	Description	Date	Author
A	Monthly Update - December, 1977; Sheet 2 annotated, Sht. 3, 4 & 5 Revised	12/6/77	K. Johnson
B	Monthly Update - January, 1978 Sheet 2 annotated, Sht. 3, 4, & 5 Revised	1/12/78	K. Johnson
C	Monthly Update - February 1978. Sheet 2 annotated, sheet 3, 4 & 5 revised. Sheet 6 (summary) added.	2/1/78	K. Johnson
D	Monthly Update - March 1978 Sheet 2 annotated, sheet 3, 4, 5, & 6 revised	3/1/78	K. Johnson
E	Monthly Update - May 1978 Sheets 3 thru 8 revised	5/16/78	K. Johnson
F	Monthly Update - August 1978 Sheet 3 Annotated, Sheet 4 thru 8 Revised.	8/21/78	R. Crawford RDC
G	Monthly Update - September 1978 Sheet 3 Annotated, Sheets 4 thru 8 Revised.	9/15/78	R. Crawford RDC
H	Monthly Update - October 1978 Sheet 3 Annotated, Sheet 4 thru 8 Revised.	10/16/78	R. Crawford RDC

The attached is an equipment configuration and weight list by functional groupings for the DE-A spacecraft as of 1 December 1977. Each major entry is marked "+" to indicate that it is a sum of the indented entries below it. Weight entries are totals for the total quantity of any given line item.

For November 1977, the margin (or allowance for growth) is shown as zero and therefore the totals represent total hardware only, not total launch weight.

During November 1977, margins were set at 10% of the spacecraft total (49.0 lb), 15% of the Instrument total (26.3 lb) and 25 lb. misc. for a total of 100.3 lb margin. Thus, the total launch weight, including margin, is 790 lb.

For December 1977, the Instrument total weight changed from 174.38 lb. to 186.06. Accordingly, the GFE margin was adjusted down to 14.62 lb to maintain a constant spacecraft weight.

The January 1978 weight report shows an additional 4.0 lb. under spacecraft structure for the antenna support hardware and an additional 3.55 lb. under GFE for PWI growth. The margin allowances have been adjusted to maintain the launch weight constant at 790 lb.

During January 1978 the weight estimate for Instruments increased by 60.2 lbs. which breaks down as follows: PWI +2.9 lbs., SAI +45.3 lbs., and RIMS +12.0 lbs. (reported as 3 heads for the first time). The total Instrumentation weight has therefore grown beyond the amount reserved for it plus all GFE margin and miscellaneous margin and has now encroached on the spacecraft margin. Total margin is now 20.9 lbs.

The March 1, 1978 issue of this report (which shows updates received thru February 1978) includes a growth of 28.5 lb. for the spacecraft which is made up of the following: structure +12.5 lb., power +7.0 lb., communications +1.3 lb., C&DH +7.7 lb. A decrease of 42.5 lb. occurred for the instruments & subtotal (all SAI).

The attached weight report for May 1978 includes all updates and the revised system baseline as of May 1.

Three columns of weight entries are given. The first, labelled "Proposal Weight" is the weight, by subsystem, at the time of the original system definition (Feb. 1977). The second column, "Target weight", is the baseline weight allocated by the NASA Delta Project Office to each subsystem or equipment and represents the authorized weight for each. Column three, "estimated/actual weight", gives the current estimate (made by the supplier) for each component. Thus, a comparison of columns 2 and 3 will show whether any component is over or under the weight allocated to it on an individual basis.

Summaries of estimated instrumentation and spacecraft weights are given on the last page where they are compared against the program totals and program margins. Totals have been changed as a result of revised Delta performance estimates and this has resulted in revised margins.

In the previous weight report for May 1978 the balance weight of 50 lbs. was shown as part of the spacecraft margin. The updated report reflects a reapportioning of this weight to the spacecraft weight which caused an apparent increase in total hardware and decrease in the margin weight.

The August 1978 weight report shows an increase of 8.6 lbs. in total hardware weight. This change was due to the following changes: Attitude control + 11.4 lbs., Power - 3.54 lbs. and GFE + .63 lbs.

In the weight report for September 1978 a total of 13.488 lbs. were lost from total hardware weight. The difference is accounted for in the following areas: Upper Hat -.9 lbs., Lower Hat -.9 lbs., RF screens +.936 lbs., ATC brackets +2.01 lbs., Upper Solar Array -2.25 lbs., Lower Solar Array -2.25 lbs., Magnetometer Sensor -.64 lbs., Magnetometer Electronics -.494 lbs., HAPI cabling -1.5 lbs., Magnetometer Astromast -4.00 lbs., and PWI Astromast -4.00 lbs.

In October the total spacecraft weight increased by 11.892 pounds in the following areas by the following amounts: Shear Panels 1 thru 6 +6.00 lbs, End Hat Upper +0.9 lbs, End Hat Lower +0.9 lbs., Upper Solar Array +2.25 lbs, Lower Solar Array +2.25 lbs., PWI Harness +2.00 lbs., Magnetometer Harness -2.90 lbs. Shear Panels increased for needed thermal conductivity. Upper and Lower Hats and Upper and Lower Solar Arrays were returned to their values of August 1978.

DYNAMICS EXPLORER DE-A
WEIGHT SUMMARY BY LEVELS
[illegible] OCTOBER 1978

ID	ITEM	PROPOSAL WEIGHT		CURRENT TARGET WEIGHT	CURRENT ESTIMATED ACT WT WEIGHT	QTY	DRWNG NO	SOURCE
[illegible]	DE-A	[illegible]	*	765.00	7?7.826	1.	2234656-501	
1011000	STRUCTURE-A-	134.?0	*	180.20	184.176	1.		
[illegible]	UPPER HP	0.0		0.0	23.400	1.		AE-C
[illegible]	LOWER HP	0.0		0.0	22.663	1.		
1011300	CEN COL/SHR P	0.0	*	0.0	29.720	1.		
1011301	CENTER COL	0.0		0.0	9.200	1.		
[illegible]	SHR PANL #1	0.0		[illegible]	3.42	1.		
[illegible]	SHR PANL #3	0.0		0.0	3.420	1.		
1011304	SHR PANL #?	0.0		0.0	3.420	1.		
1011305	SHR PANL #A	0.0		0.0	3.420	1.		
1011306	SHR PANL #?	0.0		0.0	3.420	1.		
1011307	SHR PANL #6	0.0		0.0	3.420	1.		
[illegible]	S? ADPT UPR	0.0		0.0	15.300	1.		
[illegible]	S? ADPT LWR	0.0		0.0	16.300	1.		
[illegible]	HAT UPPER	0.0	*	0.0	20.050	1.		
[illegible]	SIDES HU	0.0		0.0	15.700	1.		
[illegible]	END HU	0.0		0.0	4.350	1.		
[illegible]	HAT LOWER	0.0	*	0.0	20.050	1.		
[illegible]	SIDES HL	0.0		0.0	15.700	1.		
[illegible]	END HL	0.0		0.0	4.350	1.		
[illegible]	CENTER RING	0.0	*	0.0	16.000	1.		
[illegible]	RING	0.0		0.0	4.500	1.		
[illegible]	BRACKETS	0.0		0.0	2.500	1.		
1011000	HARDWARE	0.0		0.0	1.000	1.		
[illegible]	BRKTS+MISC	0.0		0.0	2.500	1.		
[illegible]	COVERS+SEALS	0.0		0.0	4.200	1.		
[illegible]	LIFTING HDWE	0.0		0.0	0.700	1.		
[illegible]	RF SCANS	0.0	*	0.0	2.136	1.		
1011401	[illegible] SCANS UPR	0.0		0.0	1.060	6.		
1011402	RF SCANS LWR	0.0		0.0	1.069	6.		
[illegible]	[illegible]	[illegible]		[illegible]	2.[illegible]	1.		
1011600	ANTENNA SUPT	0.0	*	0.0	4.000	1.		
1011601	HINGE MECH	0.0		0.0	1.500	1.		
[illegible]	LAUNCH SUPPT	0.0		0.0	1.500	1.		
[illegible]	RELEASE HDWR	0.0		0.0	1.000	1.		
[illegible]	ATC BRACKETS	0.0		0.0	2.019	6.		
[illegible]	ATC BRACKETS	[illegible]		[illegible]	2.[illegible]	6.		
[illegible]	THERMAL -A-	12.30	*	12.10	12.076	1.		
[illegible]	THR-UPR HAT	0.0	*	0.0	5.746	1.		
[illegible]	THR-UPR HAT	0.0		0.0	3.750	1.		
[illegible]	ATC-UPR HAT	0.0		0.0	1.992	6.		
[illegible]	THR-LWR HAT	0.0	*	0.0	5.749	1.		
[illegible]	THR-LWR HAT	0.0		0.0	3.75?	1.		
[illegible]	ATC-LWR HAT	0.0		0.0	1.998	6.		
[illegible]	THR-UPR S/P	0.0	*	0.0	0.24?	1.		
[illegible]	TEMP SENS-UB	0.0		0.0	0.240	1.		
[illegible]	THR-L? B/P	0.0	*	0.0	0.240	1.		
1020401	TEMP SENS-LB	0.0		0.0	0.240	1.		
1020500	TH HEATERS	0.1		0.0	0.130	1.		

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103 000	ATT CONTR A	62.30	+	62.30	74.300	1.		
103 100	PDY PWR SPLY	0.0		0.0	3.000	1.		
103 [illegible]	SUN SENSOR	[illegible]	+	0.0	2.300	1.		
103 301	ELECTRONICS	0.0		0.0	1.300	1.		
103 302	DETECTOR	0.0		0.0	1.000	2.		
103 400	DUT DRIVE COIL	0.0	+	0.0	25.000	1.		
103 401	DUT DAMPER	0.0		0.0	15.000	1.		
103 402	ATT COIL	0.0		0.0	12.000	2.		
103 500	MOMENT COIL	0.0		0.0	31.000	1.		
103 600	PITCH DAMPER	0.0		0.0	13.000	1.		
104 000	PWR R	120.10	+	127.10	123.560	1.		
104 100	UPPER SOL AR	0.0	+	0.0	25.780	1.	2294644-501	
104 101	CELL MODULES	0.0		0.0	24.680	1.		
104 102	SHUNT WIRING	0.0		0.0	3.100	1.		
104 103	DIODES	0.0		0.0	1.000	1.		
104 200	LOWER SOL AR	0.0	+	0.0	28.780	1.	2294744-501	
104 201	CELL MODULES	0.0		0.0	24.680	1.		
104 202	SHUNT WIRING	0.0		0.0	3.100	1.		
104 203	DIODES	0.0		0.0	1.000	1.		
104 300	BATTERIES	0.0	+	0.0	47.400	1.		
104 301	BATT 1	0.0		0.0	21.700	1.	2294642-501	
104 302	BATT 2	0.0		0.0	21.700	1.	2294642-501	
104 400	PWR SUPL EL	0.0		0.0	22.600	1.	2294640-501	
105 000	CONNECTS A	16.70	+	18.70	18.500	1.		
105 200	HARNST XPNDR	0.0		0.0	7.600	1.	2295150-1	
105 300	XPONDR CABLE	0.0		0.0	2.300	1.		
105 400	MD GN ANT SD	0.0		0.0	1.400	1.		
105 500	ANT MAST SD	0.0		0.0	1.000	1.		
105 600	SHELT NTWRK	0.0		0.0	1.800	1.		
105 900	REMOD PROC	0.0		0.0	4.400	1.		
106 000	C & DH	53.10	+	62.30	62.300	1.		
106 100	CPU	0.0		0.0	9.100	1.	2294671-501	
106 200	DMU	0.0		0.0	10.800	1.	2294673-501	
106 300	RTU	0.0		0.0	8.400	1.	2294671-501	
106 400	TAPE RECORDR	0.0	+	0.0	34.000	1.	2295174	4.16.5-2
106 401	TP RCRDR 1	0.0		0.0	17.000	1.		
106 402	TP RCRDR 2	0.0		0.0	17.000	1.		
106 500	S/C HARNESS	64.70	+	64.70	64.700	1.	2295147-501	
106 [illegible]	UPPER HARN	0.0		0.0	27.500	1.	2294647-501	
106 [illegible]	LOWER HARN	0.0		0.0	27.500	1.	2294747-501	
106 [illegible]	GROUND BLOCK	0.0		0.0	0.400	1.		
106 [illegible]	GROUND BLOCK	0.0		0.0	0.300	1.		
106 500	POTTING	0.0		0.0	1.000	1.		
106 600	CLAMPS	0.0		0.0	1.000	1.		
106 700	MAT	0.0		0.0	5.500	1.		
106 800	GRND STRAP	0.0		0.0	1.500	1.		
107 000	DEF DE-A	140.20	+	142.20	172.122	1.		
107 100	ADS	7.10	+	7.10	5.642	1.		
107 101	S MOOR	0.0		0.0	1.610	1.		
107 102	ELECTRONICS	0.0		0.0	7.032	1.		
107 103	THRSH BLNKT	0.0		0.0	0.0	1.		
107 200	MAI	0.0	+	28.00	28.560	1.	2295125-1	
107 201	PREAMPS	0.0		0.0	1.320	4.		
107 202	ELECTRONICS	0.0		0.0	21.352	1.		
107 204	SHUNT EL ANT	0.0		0.0	0.150	1.		
107 205	SW EL ANT EL	0.0		0.0	0.400	1.		
107 206	SEARCH COIL	0.0		0.0	0.300	1.		
107 207	SRCH COIL EL	0.0		0.0	0.320	1.		
107 208	LOOP ANTENNA	0.0		0.0	1.740	2.		
107 209	LOOP ANTENNA	0.0		0.0	1.360	2.		

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1091300	S41	0.0	*	34.00	34.227	1.	
1091301	VIS SENSOR	0.0		0.0	22.673	2.	2295121-2
[illegible]	VUV SENSOR	[illegible]		0.0	11.33[illegible]	1.	2295121-[illegible]
1091302	VIS COVER	0.0		0.0	1.6[illegible]	2.	
1091304	VUV COVER	0.0		0.0	2.804	1.	
1091305	CCU	0.0		0.0	1.803	1.	
1091400	HAPI	0.0	*	22.00	22.000	1.	2295120-1
1091401	ELECTRONICS	0.0		0.0	9.000	1.	
1091402	D.T ASSY	[illegible]		0.0	7.000	1.	
1091403	HVPS	0.0		0.0	1.500	1.	
1091404	PS	0.0		0.0	3.000	1.	
1091405	RAD SHLD	[illegible]		0.0	1.000	1.	
1091406	CABLING	0.0		0.0	3.500	1.	
1091500	RIMS	0.0	*	14.50	28.500	1.	
1091501	ELECTRONICS	0.0		0.0	6.000	1.	2295124-1
1091502	SENSOR	0.0		0.0	22.500	3.	2295123-2
1091600	ETU	0.0		18.40	18.400	1.	2295121-1
[illegible]	TUBULAR [illegible]	[illegible]	*	[illegible]	16.400	1.	
1091701	TUBE ANTENNA	0.0		0.0	0.960	2.	
1091702	DISPENSER	0.0		0.0	15.440	2.	
1091800	RAD WIRE 350	0.0	*	5.50	11.000	1.	
1091801	INBRD WIRE	0.0		0.0	0.320	2.	
1091802	OUTBRD WIRE	0.0		0.0	0.190	2.	
1091803	TIP MASS	[illegible]		0.0	0.22[illegible]	2.	
1091804	DISPENSER	0.0		0.0	10.554	2.	
1091900	BOOMS	0.0	*	0.0	2.000	1.	
1091901	P.T SUBASSY	0.0		0.0	2.500	1.	
1091902	P.T HINGE	0.0		0.0	1.100	1.	
1101000	BALANCE -A-	25.70	*	50.00	50.000	1.	
[illegible]	[illegible] BALANCE	[illegible]		0.0	42.35[illegible]	1.	
1101200	MAG BAL	0.0		0.0	7.650	1.	
1300000	SUPPT EQUIP	0.0	*	45.00	34.190	1.	
1300100	ASTROMST.P.I	0.0	*	0.0	16.000	1.	
1300101	MAST	0.0		0.0	2.320	1.	
1300102	ASTRO HOUS	0.0		0.0	11.680	1.	
1300200	ASTROMST.MAG	0.0	*	0.0	14.000	1.	
1300201	MAST	0.0		0.0	2.320	1.	
1300202	ASTRO HOUS	0.0		0.0	11.680	1.	
1300300	HARNESS.P.I	0.0		0.0	6.500	1.	
1300400	HARNESS,MAG	0.0		0.0	1.600	1.	
1400000	EMC REVISION	0.0		0.0	0.0	1.	

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DYNAMICS EXPLORER DE-A
ZONE AND PHASE SUMMARY
31 OCTOBER 1978

ZONE	PROPOSAL WEIGHT	CURRENT TARGET WEIGHT	CURRENT ESTIMATED WEIGHT
1	439.40	570.80	575.709
2	149.29	142.20	172.122
3	25.00	50.00	50.000

MASS	PROPOSAL WT	CURRENT TARGET WT	CURRENT EST/ACT WT
TOTAL SYSTEM LAUNCH WEIGHT INCL CAL WT	638.69	765.00	797.831
SPACECRAFT HARDWARE WEIGHT INCL CAL	464.40	572.80	575.709
GFE INSTRUMENTATION WEIGHT	149.29	142.20	172.122
TOTAL BALANCE WEIGHT	25.00	50.00	50.000

DE PROGRAM OVERVIEW WEIGHT SUMMARY

	1977		1978											
	NOV 1	DEC 1	JAN 1	FEB 1	MAR 1	APR 1	MAY 1		AUG 1	SEPT 1	OCT 1			
DE-A														
TOTAL WEIGHT	689.7	790.0	790.0	790.0	790.0		824.0		824.0	824.0	824.0			
TOTAL HDWRE	689.7	701.6	708.9	769.1	755.0		790.9		799.5	785.4	797.8			
SPACECRAFT	515.3	515.3	519.3	519.3	549.8		617.8		625.7	613.8	625.7			
INSTRUMENTS	174.4	186.1	189.6	249.8	207.2		173.1		173.8	171.6	172.1			
MARGIN		88.6	81.1	20.9	35.0		33.1		24.5	38.6	26.2			
S/C MARGIN		49.0	45.0	45.0	16.5		36.2		28.3	40.2	28.3			
INSTR MARGIN		14.6	11.1	-24.1	18.5		-3.1		-3.8	-1.6	-2.1			
MISC MARGIN		25.0	25.0											
DE-B														
TOTAL WEIGHT	772.2	883.0	883.0	883.0	883.0		862.0		862.0	862.0	862.0			
TOTAL HDWRE	772.2	772.6	776.6	776.6	805.1		810.6		805.4	801.0	797.4			
SPACECRAFT	551.2	551.2	555.2	555.2	583.7		634.3		630.6	627.9	625.1			
INSTRUMENTS	221.0	221.4	221.4	221.4	221.4		176.3		174.8	173.1	172.3			
MARGIN		110.4	106.4	106.4	77.9		51.4		56.6	61.0	64.6			
S/C MARGIN		52.6	48.6	48.6	20.1		37.7		41.4	44.1	46.9			
INSTR MARGIN		32.8	32.8	32.8	32.8		13.7		15.2	16.9	17.7			
MISC MARGIN		25.0	25.0	25.0	25.0						!			

NO REPORT

NO REPORTS

NO REPORT

NO REPORTS

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Distribution
C. Chatper
R. deBastos
W. Fuldner
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R. Horner
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J. Massari
P. Mekrasov
D. Shipley
S. Toth
File

Originating Project or Group	Note No.
DYNAMICS EXPLORER	2.4.1-005-DN

Title

DYNAMICS EXPLORER WEIGHT REPORT DE-B

Written by: K. R. Johnson K.R.Johnson	Date 1 November 1977
Approved by: W. F. Fuldner	Date --
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

Letter	Description	Date	Author
A	Monthly Update - December 1977 Sht. 2 Annotated, Sht. 3, 4, & 5 revised	12/6/77	K. Johnson KRJ
B	Monthly Update - January 1978 Sheet annotated, Sht. 3, 4, 5 revised	1/12/78	K. Johnson KRJ
C	Monthly Update - February 1978 Sheet 2 annotated, Sheet 3, 4 & 5 revised, sheet 6 (summary) added	2/1/78	K. Johnson KRJ
D	Monthly Update - March 1978 Sheet 2 annotated, Sheet 3, 4, 5, & 6, revised	3/1/78	K. Johnson KRJ
E	Monthly Update - May 1978 Sheets 3 thru 8 revised	5/16/78	K. Johnson KRJ
F	Monthly Update - August 1978 Sheet 3 Annotated, Sheet 4 thru 8 Revised	8/21/78	R. Crawford RDC
G	Monthly Update - September 1978 Sheet 3 Annotated, Sheet 4 thru 8 Revised.	9/15/78	R. Crawford RDC
H	Monthly Update - October 1978 Sheet 3 Annotated, Sheet 4 thru 8 Revised.	10/16/78	R. Crawford RDC

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The attached is an equipment configuration and weight list by functional groupings for the DE-B spacecraft as of 1 December 1977. Each major entry is marked "+" to indicate that it is a sum of the indented entries below it. Weight entries are totals for the total quantity of any given line item.

For November 1977, the margin (or allowance for growth) is shown as zero and therefore the totals represent total hardware only, not total launch weight.

During November 1977, margins were set at 10% of the spacecraft total (52.6 lb), 15% of the instrument total (33.2 lb) and 25 lb misc. for a total margin of 110.8 lb. Thus the total launch weight, including margin is 883 lb.

For December 1977, the instrument total weight changed from 221.0 lb to 221.4 lb. Accordingly, the GFE margin was adjusted down to 32.8 lb. to maintain a constant spacecraft weight.

The January 1978 weight report includes an additional 4.0 lb. under spacecraft structure for the antenna support. No other weight changes were noted. Spacecraft margin has been adjusted to maintain the system launch weight constant at 883 lb.

No changes reported during January 1978.

During February 1978, the spacecraft weight increased by 28.5 lb. as follows: structure +9.5 lb., power +7.0 lb., communications +4.3 lb., C&DH +7.7 lb. No changes were reported for GFE instruments and support equipment.

The attached weight report for May 1978 includes all updates and the revised system baseline as of May 1.

Three columns of weight entries are given. The first, labelled "Proposal Weight" is the weight, by subsystem, at the time of the original system definition (Feb. 1977). The second column, "Target weight", is the baseline weight allocated by the NASA Delta Project Office to each subsystem or equipment and represents the authorized weight for each. Column three, "estimated/actual weight", gives the current estimate (made by the supplier) for each component. Thus, a comparison of columns 2 and 3 will show whether any component is over or under the weight allocated to it on an individual basis.

Summaries of estimated instrumentation and spacecraft weights are given on the last page where they are compared against the program totals and program margins. Totals have been changed as a result of revised Delta performance estimates and this has resulted in revised margins.

The May 1978 weight report now reflects a shifting of the balance weight from the margin item to the spacecraft weight category. This caused an apparent increase of 25 lbs. in the total hardware weight and a decrease of 25 lbs. in the margin weight.

The weight report for August 1978 reflects changes in; Attitude Control of - 7.5 lbs., Power + 3.81 and GFE of - 1.5 lbs. The result was an overall decrease of 5.2 lbs. to the total hardware weight.

The September weight report shows a decrease of 4.36 lbs. The changes occurred in the following areas: ATC brackets +1.34 lbs., LAPI EPD system -1.9 lbs., and magnetometer Astromast -4.00 lbs.

The weight changes for October are: Magnetometer Sensor -0.640 lbs., Magnetometer Electric -0.062 lbs., Magnetometer Harness -2.90 lbs. Total weight change amounted to -3.602 pounds. Note the Magnetometer Sensor and Magnetometer Electric weights were inadvertently changed in the wrong program in the last weight update.

DYAMICS EXPLORER DE-B
WEIGHT SUMMARY BY LEVELS
31 OCTOBER 1978

ID	NAME	PROPOSAL WEIGHT		CURRENT TARGET WEIGHT	CURRENT ESTIMATED ACT WT	QTY	DRWNG NO	SOURCE
1000000	DE-B	682.68	+	761.40	797.391	1.	2294700-501	
1010000	STRUCTURE-B-	136.90	+	165.80	162.160	1.		
1010100	UPPER BP	0.0		0.0	23.400	1.		AE-C
1010200	LOWER BP	0.0		0.0	22.800	1.		
1010300	CEN COL/SHR P	0.0	+	0.0	23.720	1.		
1010301	CENTER COL	0.0		0.0	9.200	1.		
1010302	SHR PANL 1	0.0		0.0	2.420	1.		
1010303	SHR PANL 2	0.0		0.0	2.420	1.		
1010304	SHR PANL 3	0.0		0.0	2.420	1.		
1010305	SHR PANL 4	0.0		0.0	2.420	1.		
1010306	SHR PANL 5	0.0		0.0	2.420	1.		
1010307	SHR PANL 6	0.0		0.0	2.420	1.		
1010500	SEC ATPT LWR	0.0		0.0	15.300	1.		
1010600	HAT UPPER	0.0	+	0.0	20.050	1.		
1010601	SIDES HU	0.0		0.0	15.700	1.		
1010602	END HU	0.0		0.0	4.350	1.		
1010700	HAT LOWER	0.0	+	0.0	20.050	1.		
1010701	SIDES HL	0.0		0.0	15.700	1.		
1010702	END HL	0.0		0.0	4.350	1.		
1010800	CENTER RING	0.0	+	0.0	16.000	1.		
1010801	RING	0.0		0.0	6.500	1.		
1010802	BRACKETS	0.0		0.0	9.500	1.		
1010900	MAG SUPPT CO	0.0		0.0	3.400	1.		
1011000	HARDWARE	0.0		0.0	1.000	1.		
1011100	BRKTS,MISC	0.0		0.0	2.500	1.		
1011200	COVERS+SEALS	0.0		0.0	4.200	1.		
1011300	LIFTING HDWR	0.0		0.0	1.200	1.		
1011400	RF SCREENS	0.0		0.0	1.200	4.		
1011500	HDWRE SOV	0.0		0.0	2.000	1.		
1011600	ANTENNA SUPT	0.0	+	0.0	4.000	1.		
1011601	SUL GS BIPD	0.0		0.0	1.500	1.		
1011602	HI GS BRKTRY	0.0		0.0	2.500	1.		
1011700	ATC BRACKETS	0.0		0.0	1.340	4.		
1020000	THERMAL -B-	10.40	+	10.50	10.460	1.		
1020100	THR-UPR HAT	0.0	+	0.0	6.150	1.		
1020101	THR-UPR HAT	0.0		0.0	3.750	1.		
1020102	ATC-UPR HAT	0.0		0.0	2.400	4.	2271611-503	
1020300	THR-UPR B/P	0.0	+	0.0	0.240	1.		
1020301	TEMP SENS-UB	0.0		0.0	0.240	1.		
1020400	THR-LWR B/P	0.0	+	0.0	3.990	1.		
1020401	TEMP SENS-LB	0.0		0.0	0.240	1.		
1020402	THR-LWR B/P	0.0		0.0	3.750	1.		
1020500	TH HEATERS	0.0		0.0	0.100	1.		
1030000	ATT CONTR B	99.70	+	100.10	92.600	1.		
1030200	PITCH CON	0.0		0.0	8.400	1.	2271623-501	
1030300	SUN SENSOR	0.0	+	0.0	3.800	1.		
1030301	DETECTORS	0.0		0.0	1.600	2.		
1030302	ELECTRONICS	0.0		0.0	2.200	2.		
1030400	NUT DPR+COIL	0.0	+	0.0	28.400	1.		

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1[illegible]61	[illegible]OUT DIMPLR	0.0		0.0	16.400	1.	
1[illegible]492	[illegible]TT [illegible]COIL	0.0		0.0	12.000	2.	
1[illegible]50[illegible]	PITCH COIL	[illegible]		0.0	[illegible]	1.	
1[illegible]700	[illegible]OR [illegible]HL ASSY	[illegible]	*	0.0	44.600	1.	
1[illegible]761	[illegible]OTOR ASSY	0.0		0.0	22.300	1.	
1[illegible]7[illegible]	INERTIA [illegible]HL	[illegible]		0.0	22.300	1.	
1[illegible]800	[illegible]HL HOR SENS	0.0		0.0	2.000	1.	
1[illegible]900	MAG SHIELD	0.0		0.0	2.400	1.	
1[illegible]6666	P[illegible]-8	126.10	*	127.10	136.510	1.	
1[illegible]100	[illegible]UTER SOL [illegible]S	0.0	*	0.0	25.860	1.	2296644-502
1041101	CELL MODULES	0.0		0.0	26.090	1.	
1[illegible]100	[illegible]SHUNT WIRING	[illegible]		[illegible]	[illegible]	1.	
1[illegible]102	DIODES	0.0		0.0	[illegible]	1.	
1[illegible]201	L[illegible]GER SOL AS	0.0	*	0.0	35.050	1.	2294744-502
1[illegible]201	CELL MODULES	[illegible]		[illegible]	[illegible]	1.	
1[illegible]202	SHUNT WIRING	0.0		0.0	3.350	1.	
1[illegible]203	DIODES	0.0		0.0	1.060	1.	
1[illegible]3[illegible]	BATTERIES	[illegible]	*	[illegible]	43.400	1.	
1[illegible]301	BATT 1	0.0		0.0	21.700	1.	2294642-501
1[illegible]302	BATT 2	0.0		0.0	21.700	1.	2294642-501
1[illegible]400	[illegible]UN SHEL [illegible]	[illegible]		[illegible]	[illegible]	1.	[illegible]294644-501
1[illegible]000	[illegible]ONNECTOR,[illegible]	24.56	*	33.20	33.200	1.	
1[illegible]100	[illegible]ASS [illegible]OOR	0.0		0.0	15.000	1.	2295161-1
1[illegible]300	[illegible]ROUND CABLE	[illegible]		[illegible]	2.300	1.	
1[illegible]500	LOW GAIN ANT	0.0		0.0	1.400	1.	
1[illegible]600	MID GAIN ANT	0.0		0.0	7.100	1.	
1[illegible]700	SHEET METAL	[illegible]		[illegible]	2.100	1.	
1[illegible]800	[illegible]REMOD PROC	0.0		0.0	4.400	1.	
1[illegible]900	C[illegible]ON	53.10	*	62.30	62.300	1.	
1[illegible]100	[illegible]T	[illegible]		[illegible]	[illegible]	1.	[illegible]294673-501
1[illegible]200	[illegible]OD	0.0		0.0	10.800	1.	2294673-501
1[illegible]400	[illegible]TM	0.0		0.0	8.400	1.	2294671-501
1[illegible]600	[illegible]ARE [illegible]CCORDN	[illegible]		[illegible]	[illegible]	2.	[illegible]-16-5-1
1[illegible]800	S/C HARNESS	64.70	*	64.70	64.700	1.	2295147-502
1[illegible]100	[illegible]UPER HARN	0.0		0.0	27.500	1.	2294647-502
1[illegible]200	[illegible]UMA HARN	[illegible]		[illegible]	[illegible]	1.	[illegible]294747-502
1[illegible]300	[illegible]R GND BLOCK	0.0		0.0	0.400	1.	
1[illegible]400	[illegible]ERIES BLOCK	0.0		0.0	0.300	1.	
1[illegible]500	[illegible]UTTER	[illegible]		[illegible]	1.000	1.	
1[illegible]600	CLAMPS	0.0		0.0	1.000	1.	
1[illegible]700	HAT	0.0		0.0	5.500	1.	
1[illegible]800	[illegible]OOL STRAP	[illegible]		[illegible]	1.500	1.	
1[illegible]900	SFE DE-6	150.42	*	122.10	172.348	1.	
1[illegible]100	[illegible]FE	0.0	*	9.90	59.100	1.	
1[illegible]101	[illegible]UBULAR ANT	[illegible]		[illegible]	[illegible]	6.	
1[illegible]102	PREAMPS	0.0		0.0	3.300	6.	2295136-2
1[illegible]103	ELECTRONICS	0.0		0.0	6.600	1.	2295135-1
1[illegible]104	[illegible]ISPENSER	1.0		0.0	36.456	6.	
1[illegible]200	[illegible]SS	0.0	*	7.10	8.148	1.	
1[illegible]201	[illegible]ENSOR	0.0		0.0	1.010	1.	2295124-2
1[illegible]202	ELECTRONICS	[illegible]		[illegible]	[illegible]	1.	2295124-1
1[illegible]203	THRML BLNKT	0.0		0.0	0.0	1.	"
1[illegible]300	I[illegible]	0.0	*	7.30	7.500	1.	"
1[illegible]301	[illegible]LECTRONICS	[illegible]		[illegible]	[illegible]	1.	2295136-1
1[illegible]302	SENSOR	0.0		0.0	3.431	1.	2295136-2
1[illegible]400	L-BI	0.0	*	30.00	30.000	1.	2295135-1
1[illegible]401	[illegible]ELECTORS	[illegible]		[illegible]	[illegible]	1.	
1[illegible]402	SIDE PLATE	0.0		0.0	2.300	1.	
1[illegible]403	TOP PLATE	0.0		0.0	0.800	1.	
1[illegible]404	HOUSE	[illegible]		[illegible]	[illegible]	1.	

1[illegible]407	CABLING	0.0		0.0	1.500	1.	
1[illegible]436	PPS	0.0		0.0	4.000	2.	
1[illegible]409	HVPS	0.0		0.0	2.400	2.	
1[illegible]410	PPD SYST	0.0		0.0	0.500	1.	
1[illegible]411	SEP	0.0		0.0	6.000	1.	
1[illegible]412	[illegible]ELTS	0.0		0.0	1.000	1.	
1[illegible]413	TOP BUNKT	0.0		0.0	0.200	1.	
1[illegible]414	MAG SENSOR	0.0		0.0	0.750	1.	
1[illegible]415	MAG DEPLOYER	0.0		0.0	0.750	1.	
1[illegible]500	MACS	0.0	◆	17.00	17.000	1.	
1[illegible]501	ELECTRONICS	0.0		0.0	6.000	1.	2295131-2
1[illegible]502	INSTRUMENT	0.0		0.0	10.108	1.	2295131-1
1[illegible]503	C VER	0.0		0.0	0.892	1.	
1[illegible]600	FPI	0.0	◆	19.00	19.000	1.	2295133-1
1[illegible]601	ELECTRONICS	0.0		0.0	5.800	1.	
1[illegible]602	INSTRUMENT	0.0		0.0	12.625	1.	
1[illegible]603	CABLING	0.0		0.0	0.200	1.	
1[illegible]604	C VER	0.0		0.0	0.375	1.	
1[illegible]700	GAIC	0.0	◆	17.00	17.000	1.	
1[illegible]701	ELECTRONICS	0.0		0.0	8.000	1.	2295132-1
1[illegible]702	SENSOR	0.0		0.0	9.108	1.	2295132-3
1[illegible]703	COVER	0.0		0.0	0.892	1.	
1[illegible]800	LAS	0.0	◆	6.00	6.000	1.	2295137
1[illegible]801	SIG PROC	0.0		0.0	3.900	1.	
1[illegible]802	FILTER BOX	0.0		0.0	1.000	2.	
1[illegible]803	LATCH	0.0		0.0	0.400	2.	
1[illegible]804	[illegible]POSE	0.0		0.0	0.500	2.	
1[illegible]865	CABLING	0.0		0.0	0.200	1.	
1[illegible]900	HDR	0.0	◆	8.80	8.600	1.	
1[illegible]901	ELECTRONICS	0.0		0.0	4.800	1.	2295134-1
1[illegible]902	SENSOR	0.0		0.0	3.800	1.	2295134
1100000	BALANCE -S-	0.0	◆	25.00	25.000	1.	
1[illegible]106	S/C BALANCE	0.0		0.0	20.810	1.	
1[illegible]200	[illegible]TAL	0.0		0.0	4.150	1.	
130[illegible]000	SUPT EQUIP	22.50	◆	50.60	43.700	1.	
130[illegible]100	[illegible]DMS	22.50	◆	22.50	14.000	1.	
1301[illegible]01	ASTRONAST	0.0		0.0	2.323	1.	
1301[illegible]02	ASTRO BOOM	0.0		0.0	11.677	1.	
1302[illegible]06	HARNESS MAG	0.0		0.0	1.600	1.	
1303[illegible]00	SCAN PLATFOR	0.0	◆	28.10	28.100	1.	
1303301	MTG PLATE	0.0		0.0	9.400	1.	
1303[illegible]02	DRIVE	0.0		0.0	9.400	1.	
1303303	IFCE ELECTR	0.0		0.0	3.500	1.	
1303304	DRIVE ELECTR	0.0		0.0	5.800	1.	
1401000	EMC REVISION	0.0	◆	0.0	0.0	1.	

DYAMICS EXPLORER DE-B
ZONE AND PHASE SUMMARY
21 OCTOBER 1978

ZONE	PROPOSAL WEIGHT	CURRENT TARGET WEIGHT	CURRENT ESTIMATED WEIGHT
1	531.76	614.30	660.046
2	150.92	122.10	172.348
3	0.0	25.00	25.000

PHASE	PROPOSAL WT	CURRENT TARGET WT	CURRENT EST/ACT WT
TOTAL SYSTEM LAUNCH WEIGHT INCL BAL WT	682.68	761.40	797.394
SPACECRAFT HARDWARE WEIGHT INCL BAL	531.76	614.30	660.046
GFE INSTRUMENTATION WEIGHT	150.92	122.10	172.348
TOTAL BALANCE WEIGHT	0.0	25.00	25.000

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DE PROGRAM OVERVIEW WEIGHT SUMMARY

	1977		1978											
	NOV 1	DEC 1	JAN 1	FEB 1	MAR 1	APR 1	MAY 1		AUG 1	SEPT 1	OCT 1			
DE-A														
TOTAL WEIGHT	689.7	790.0	790.0	790.0	790.0		824.0		824.0	824.0	824.0			
TOTAL HDWRE	689.7	701.6	708.9	769.1	755.0		790.9		799.5	785.4	797.8			
SPACECRAFT	515.3	515.3	519.3	519.3	549.8		617.8		625.7	613.8	625.7			
INSTRUMENTS	174.4	186.1	189.6	249.8	207.2		173.1		173.8	171.6	172.1			
MARGIN		88.6	81.1	20.9	35.0		33.1		24.5	38.6	26.2			
S/C MARGIN		49.0	45.0	45.0	16.5		36.2		28.3	40.2	28.3			
INSTR MARGIN		14.6	11.1	-24.1	18.5		-3.1		-3.8	-1.6	-2.1			
MISC MARGIN		25.0	25.0											
DE-B														
TOTAL WEIGHT	772.2	883.0	883.0	883.0	883.0		862.0		862.0	862.0	862.0			
TOTAL HDWRE	772.2	772.6	776.6	776.6	805.1		810.6		805.4	801.0	797.4			
SPACECRAFT	551.2	551.2	555.2	555.2	583.7		634.3		630.6	627.9	625.1			
INSTRUMENTS	221.0	221.4	221.4	221.4	221.4		176.3		174.8	173.1	172.3			
MARGIN		110.4	106.4	106.4	77.9		51.4		56.6	61.0	64.6			
S/C MARGIN		52.6	48.6	48.6	20.1		37.7		41.4	44.1	46.9			
INSTR. MARGIN		32.8	32.8	32.8	32.8		13.7		15.2	16.9	17.7			
MISC MARGIN		25.0	25.0	25.0	25.0						!			

NO REPORT

NO REPORTS

NO REPORTS

Design Note

RCA Astro Electronics Division

Originating Project or Group	Note No.
	2.4.1-013

Title

Spacecraft Configuration and Mass Properties, DE-A and -B

Written by: R. Crawford R D Crawford	Date 10-19-78
Approved by: K. R. Johnson K R Johnson	Date 19 October 1978
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

Letter	Description	Date	Author

1. Scope

This design note describes the "Spacecraft Configuration Reporting System" which is a computer program used to build and display a record of the physical characteristics of a spacecraft system. A Weight Report and Moment of Inertia Report are provided for the stowed and deployed configurations. Sketches of the configurations upon which the report was based are included as figures 1 thru 8 with their respective weights, inertias and inertia ratios.

2. Analytical Approach, Program Description

2.1 Weight Report

The Weight Report consists of three segments. First a weight summary is produced which lists the identification number, date the item was input, name, drawing number, source, zone, proposal weight, target weight, estimated or actual weight, percentage weight tolerance, weight tolerance, and quantity. This listing is primarily a display of the values input. The proposal weight is an initial estimated weight. The target is the desired weight for the component and is the current contact baseline weight. The estimated or actual weight is the current estimate of a component's weight or an actual value determined by weighing the component. The percentage weight tolerance is the allowable variation of the estimated or actual weight. The weight tolerance is this percentage of the estimated or actual weight.

The second segment of the Weight Report is an indented summary. The weights are summed to each level and printed in an indented list. That is, all level four components are summed to level three so that a box level printout would reflect the total of all components included. Similarly, level three is summed to level two which in turn is totaled to the highest level. The names appear indented to indicate the level.

2.2 Inertia Report

The final section of the program is a moment of inertia routine. The inertia of each component may be calculated or input. This provides an inertia in the component's frame of reference. If the component is not in the system reference frame (parallel to the system reference axis), the angles must be input through which the component will be rotated. With the distance to the system reference specified, the center of gravity of the system is located. Finally, the system can be dynamically balanced by indicating the position of the balance weights. For most geometric shapes, inertia calculations can be done in the program. For those with odd shapes, hand calculations must be made and the inertias input.

The program prints a list of all the inertia related input. The weight for each component is obtained from the weight data base established in Section 2.1 of the program. This is followed by a list of the inertias of each component in its reference frame.

3. Results of Analysis

3.1 Stowed Configuration

3.1.1 DE-A

The Inertia Report is based on Figures 1, 2, 3, and 4. The center of gravity of the stowed configuration is located at booster station 549.45 after balance weights have been added. The following data was taken from Appendix A.

The Inertias before balancing are:

$$I = \begin{bmatrix} 260744.81 & -1726.22 & -2288.39 \\ -1726.22 & 274844.06 & -2770.29 \\ -2288.39 & -2770.29 & 294752.31 \end{bmatrix} \text{lbs.-in}^2$$

The ratio of spin axis inertia to maximum transverse inertia is 1.072.

Total balance weight required 26.8754 lbs.* computed on the basis of static and dynamic balance requirements.

Inertia matrix after balancing is:

$$I = \begin{bmatrix} 270639.12 & -1767.08 & 0.0 \\ -1767.08 & 288072.75 & 0.0 \\ 0.0 & 0.0 & 305667.94 \end{bmatrix} \text{lbs.-in}^2$$

or

$$I = \begin{bmatrix} 701.06 & -4.58 & 0.0 \\ -4.58 & 746.22 & 0.0 \\ 0.0 & 0.0 & 791.80 \end{bmatrix} \text{in-lbs.-sec}^2$$

The inertia ratio of the maximum transverse inertia to the spin axis inertia is 1.060. (See Appendix A, after balancing)

3.1.2 DE-B

The B Inertia Report is based on Figures 1, 5, and 6. The center of gravity after balancing is located at booster station 491.75. The following data may be found in Appendix C.

Before balancing the inertias are:

$$I = \begin{bmatrix} 276181.37 & 579.51 & 1038.84 \\ 579.51 & 275851.0 & 5776.33 \\ 1038.84 & 5776.33 & 282365.56 \end{bmatrix}$$

The inertia ratio is 1.021

*Note: Balance weight will be reduced by base plate layout alterations.

Total balance weight required 13.63 lbs.* and is computed based on static balance requirements.

Inertia matrix after balancing is:

$$I = \begin{bmatrix} & \text{TBS} & \end{bmatrix}$$

$$I = \begin{bmatrix} & & \end{bmatrix}$$

The inertia ratio is equal to

3.1.3 Stacked - Stowed Configuration

Figure 1 shows the stacked configuration of DE-A and DE-B. The center of gravity is at booster station 520.485.

The stacked-stowed inertias about the center of gravity are:

$$Ixx = 1.8718 \times 10^6 \text{ lbs.-in}^2$$
$$Iyy = 1.9034 \times 10^6 \text{ lbs.-in}^2$$
$$Izz = 5.6833 \times 10^5 \text{ lbs.-in}^2$$

The above values were derived using data contained in Appendices A and C.

3.2 Deployed Configurations

3.2.1 DE-A

The Inertia Report for the deployed configuration of DE-A was based on Figures 2, 3, 4, and 7. The following data was taken from Appendix B.

$$I = \begin{bmatrix} 1918599.0 & -264734.25 & -1711.18 \\ 264734.25 & 1437994.0 & -4896.06 \\ -1711.18 & -4896.06 & 3083282.0 \end{bmatrix} \text{ lbs. in}^2$$

The inertia ratio is 1.515

3.2.2 DE-B

Figures 5, 6, and 8 were used when making the Inertia Report. The following data may also be found in Appendix D.

$$I = \begin{bmatrix} & & \end{bmatrix} \text{ lbs. -in}^2$$

With an inertia ratio of 0.983.

*Note: Balance weight will be reduced by base plate layout alterations.

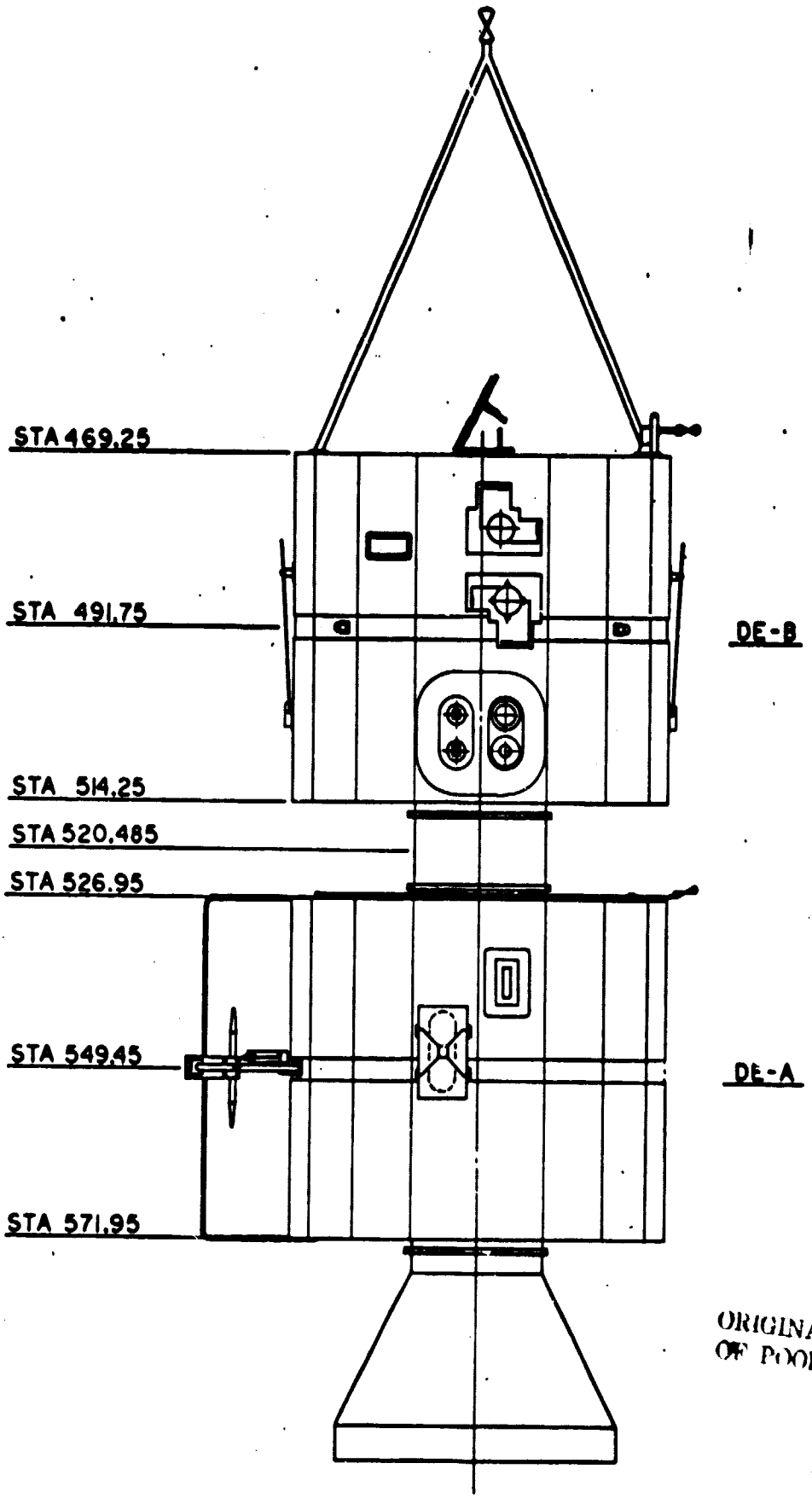
4. Interpretation of Results

The weight data base after initially being created is periodically and systematically updated to show changes in the weight of the spacecraft. This weight data base, in addition to being a weight accounting system, is used as an input for inertia calculations.

The base plate configurations contained in this report, Figures 2, 3, 4, 5, and 6, are preliminary and will be modified to reduce the balance weight required. As more detailed information on box configurations and centers of gravity are made available, the inertia file will be updated.

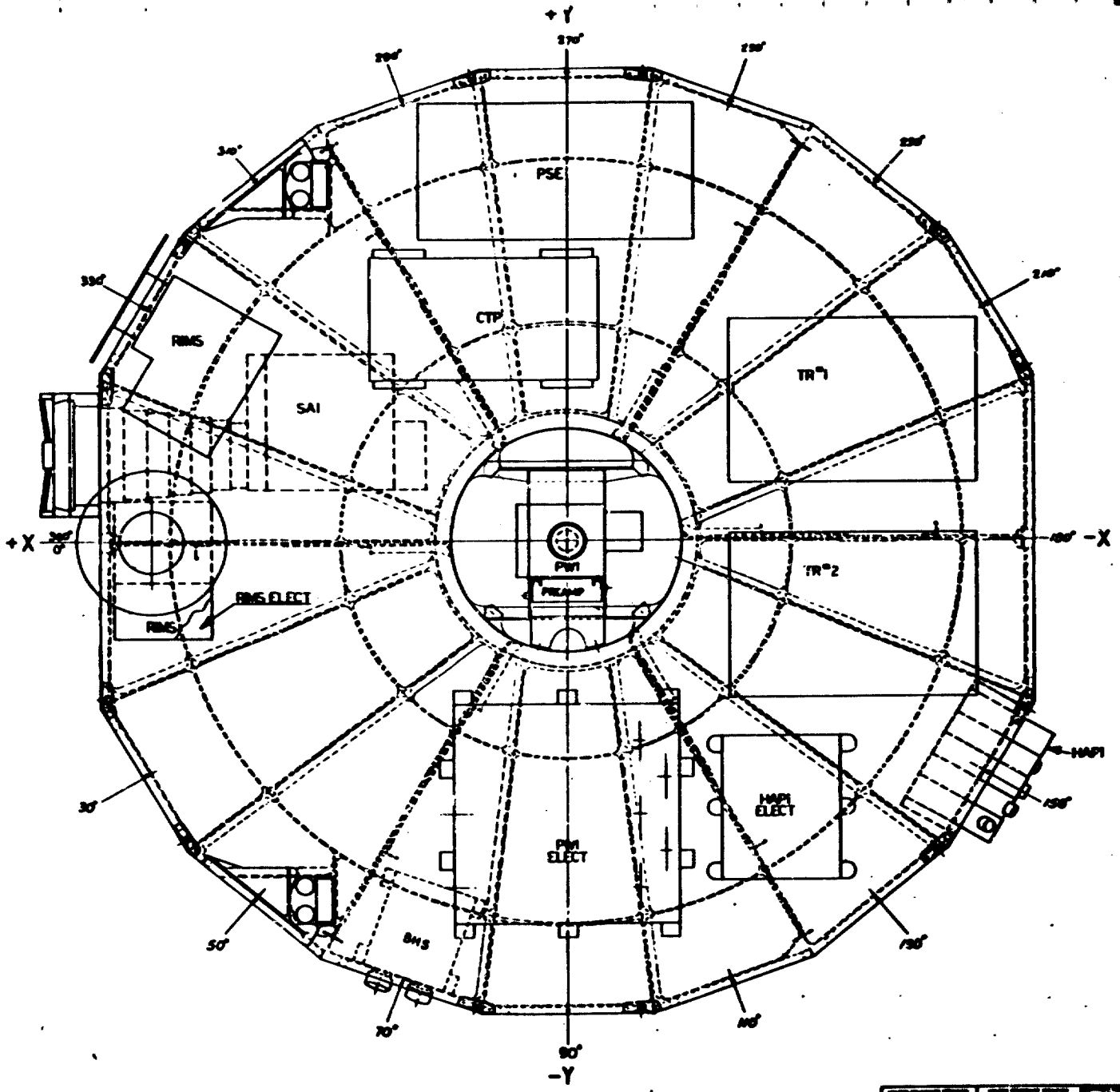
The Inertia Report consists of five sections. Section one is a listing of components: locations, denoted by XBAR, YBAR, ZBAR, dimensions, LX, LY and LZ or inertias, Ixx, Iyy, and Izz; inner and outer radius if applicable and the weights. Section two is a listing by components of their respective inertias. Section three gives the information contained in Section two as well as the products of inertias resulting from a rotation of axes. Section four lists inertias of components relative to the spacecraft reference axes. Section five can appear in two forms; no balancing done on spacecraft and with balancing calculations. In either case, an output of the summation of component weights times their respective radi of gyration is printed. These values do not account for the components own local inertia (inertia about its own c.g.). If balancing is to be done, the balance weight position is input and the balance weight required at this location is calculated. In both cases the inertia matrix is calculated in two sets of units. The center of gravity is also calculated.

FIGURES



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FIG. 1 STACKED - STOWED CONFIGURATION



F14.2

UPPER BASEPLATE DE-A

EQUIPMENT INSTALLATION DE-A

E 49671 2294617

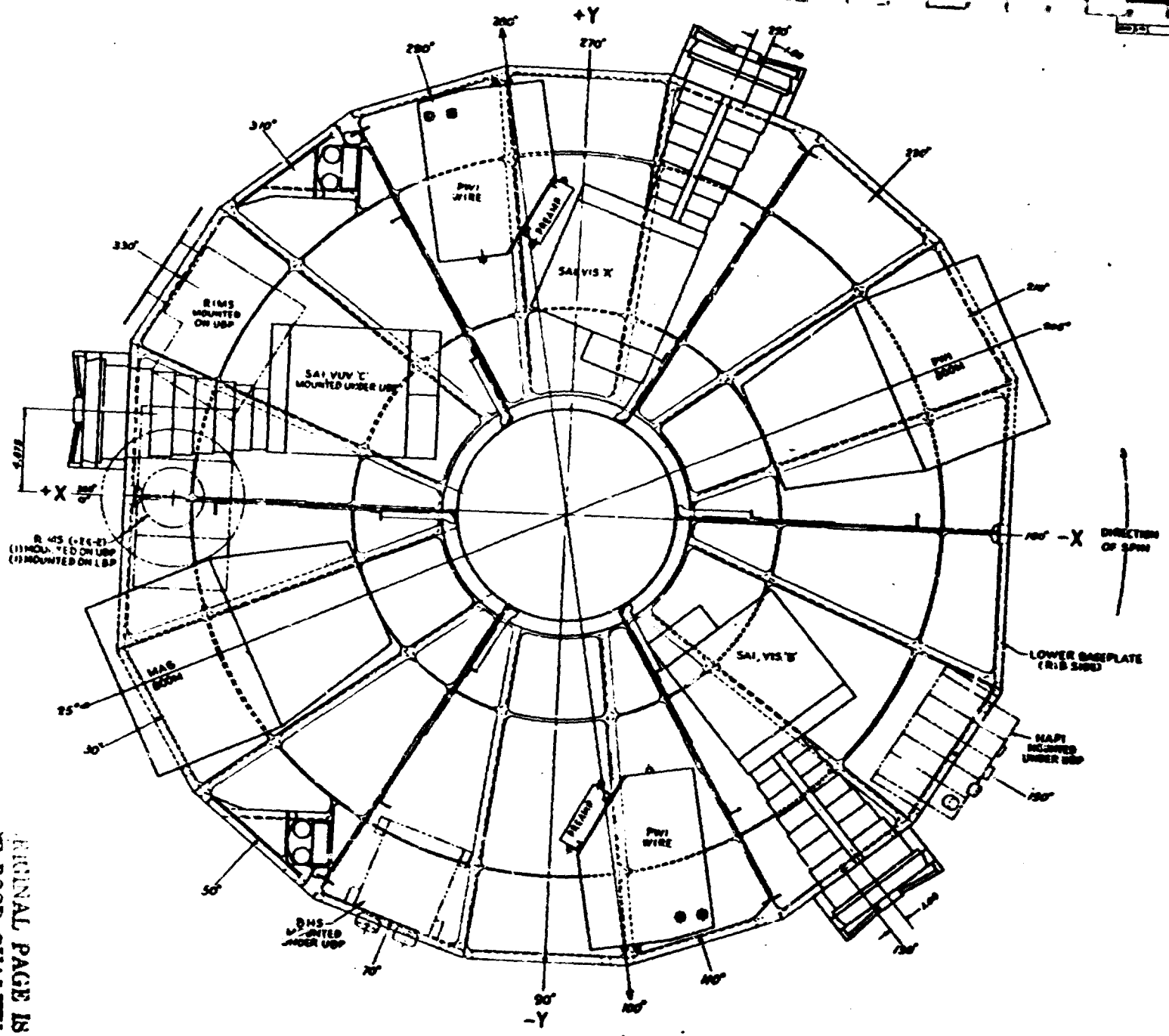
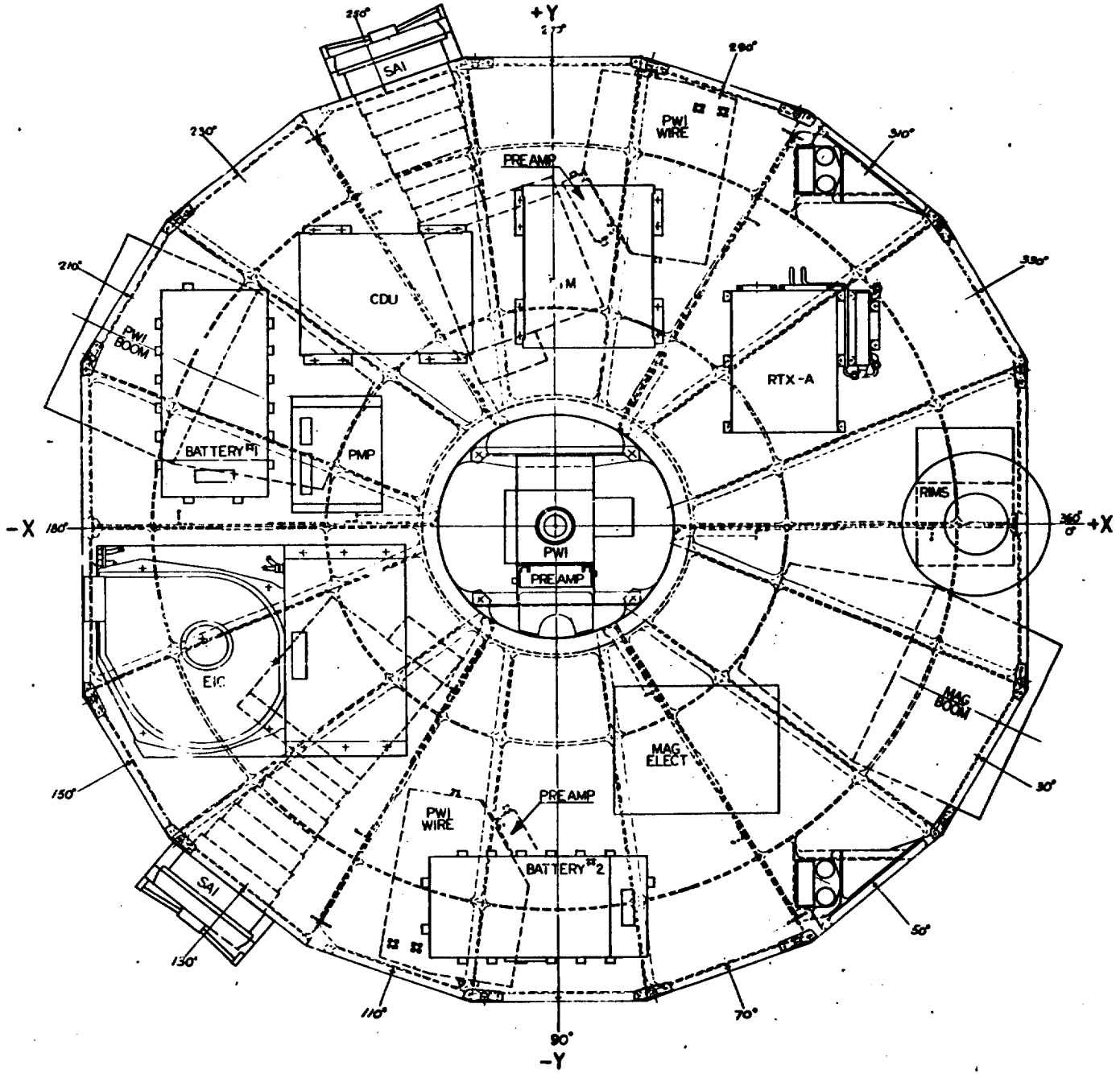


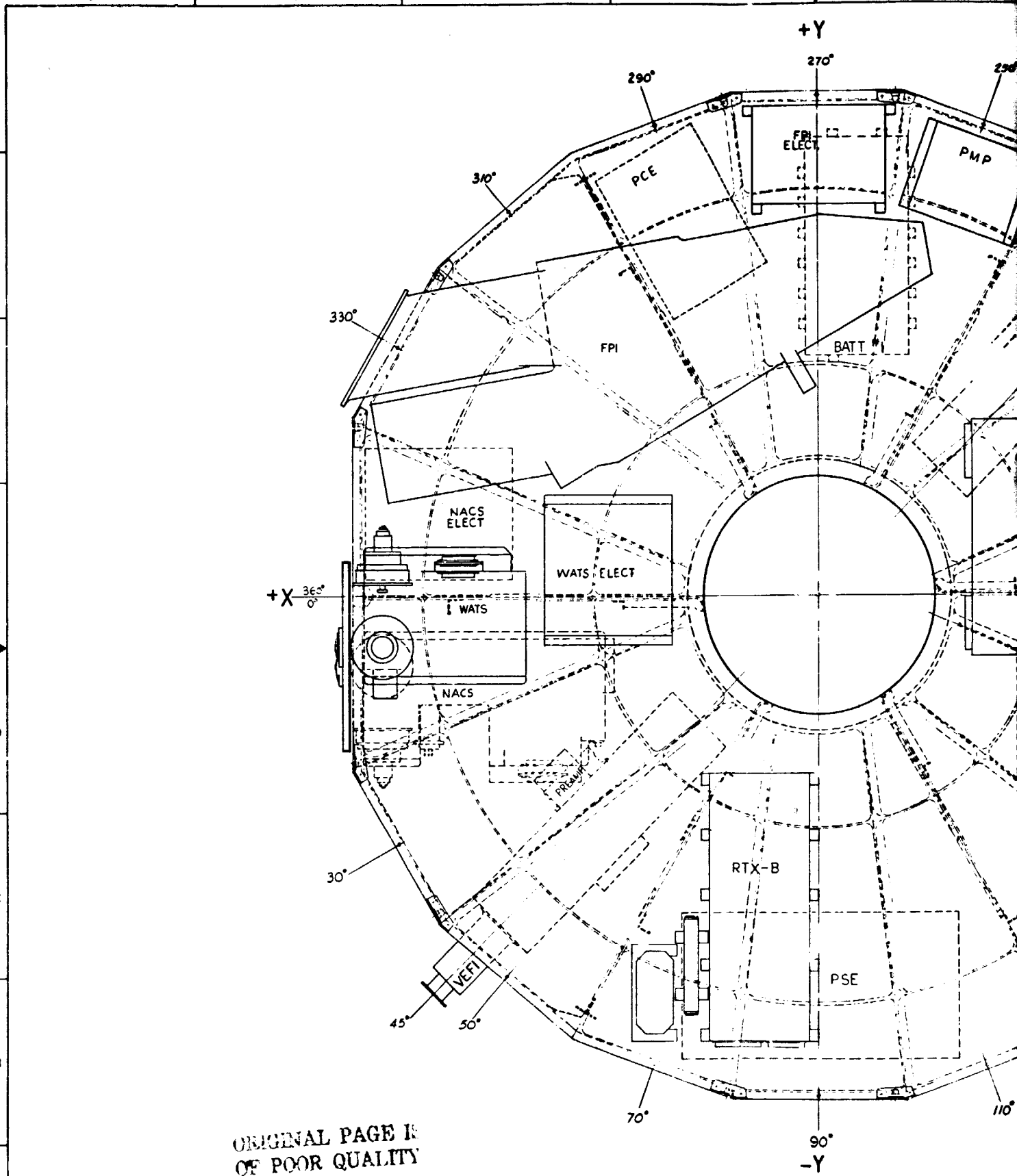
FIG. 3

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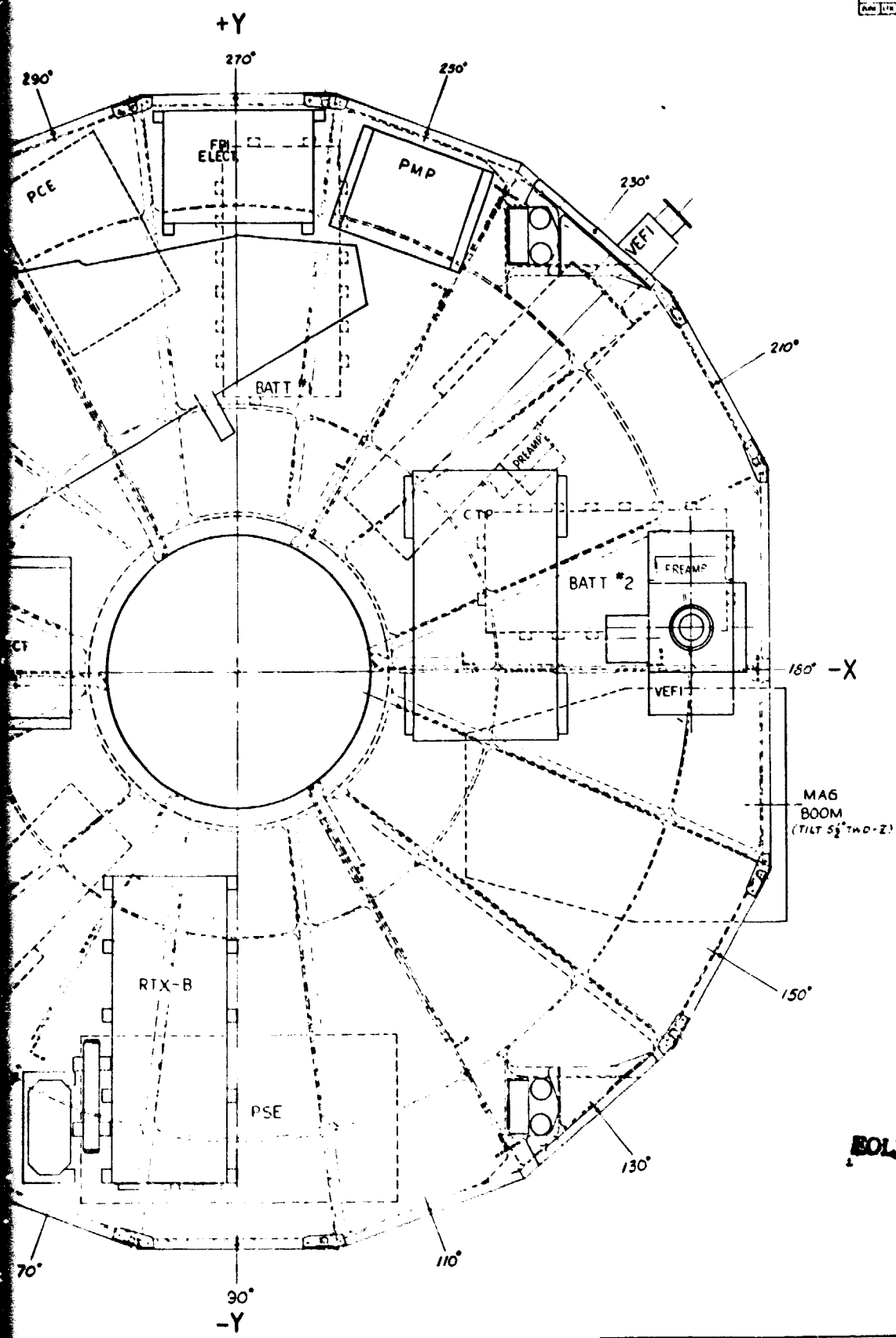


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LOWER BASEPLATE DE-A



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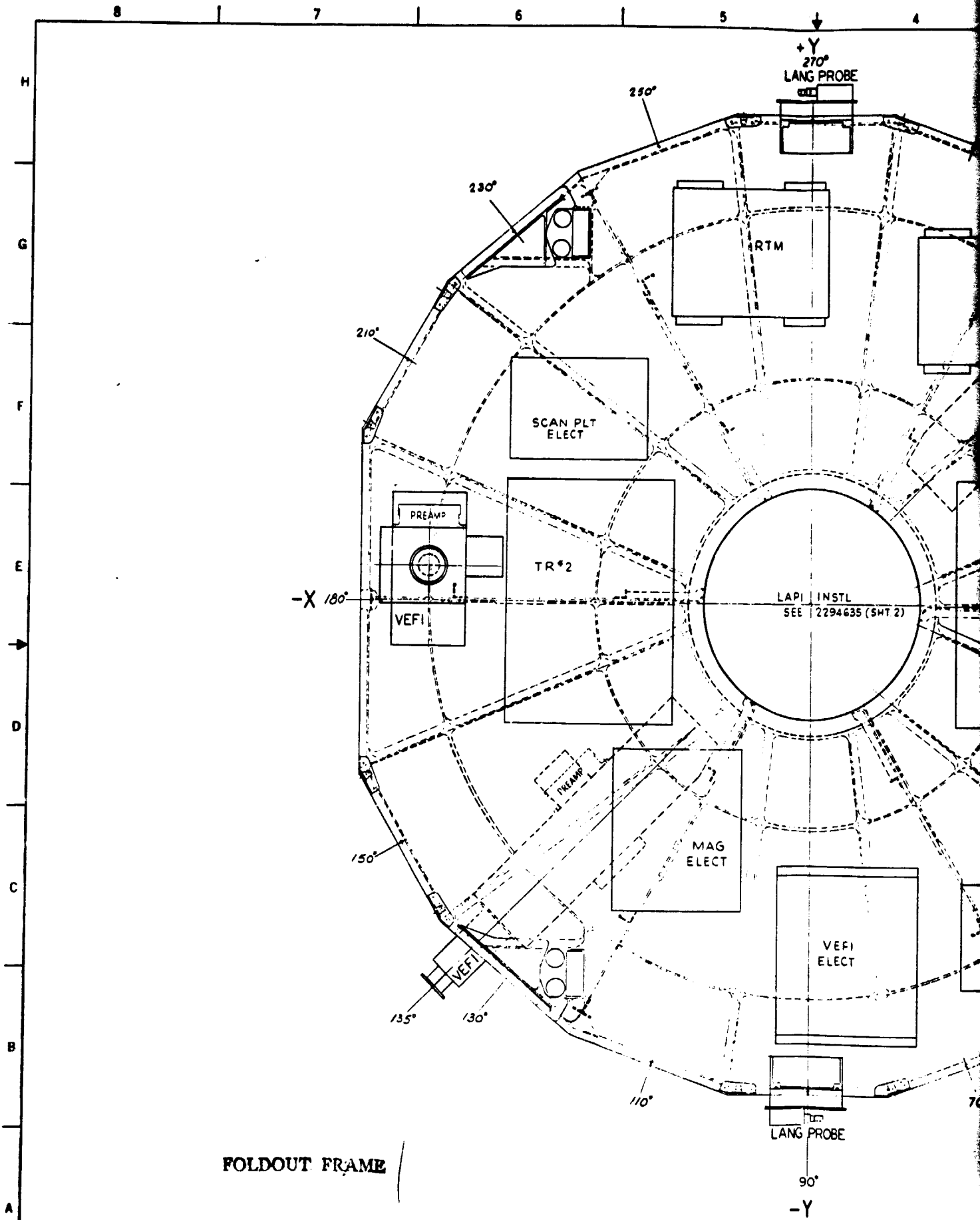
BOLDOUT FRAME

Figure 5

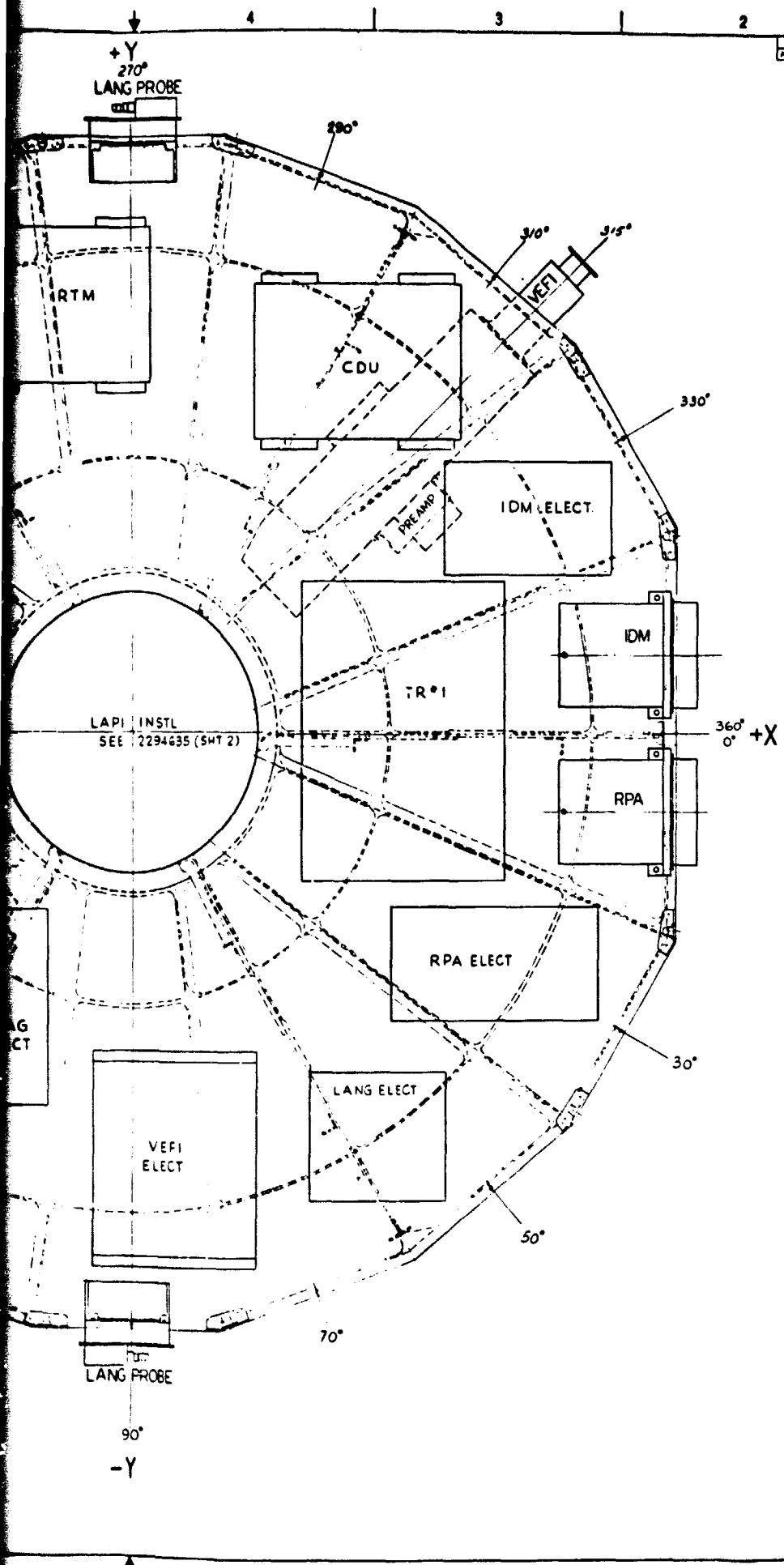
UPPER BASEPLATE DE-B

	EQUIPMENT INSTALLATION DE-B
E 19671	2294717

2294717



FOLDOUT FRAME



2

FOLDOUT FRAME

Figure 6

LOWER BASEPLATE DE-B

E 49671 2294717

2294717

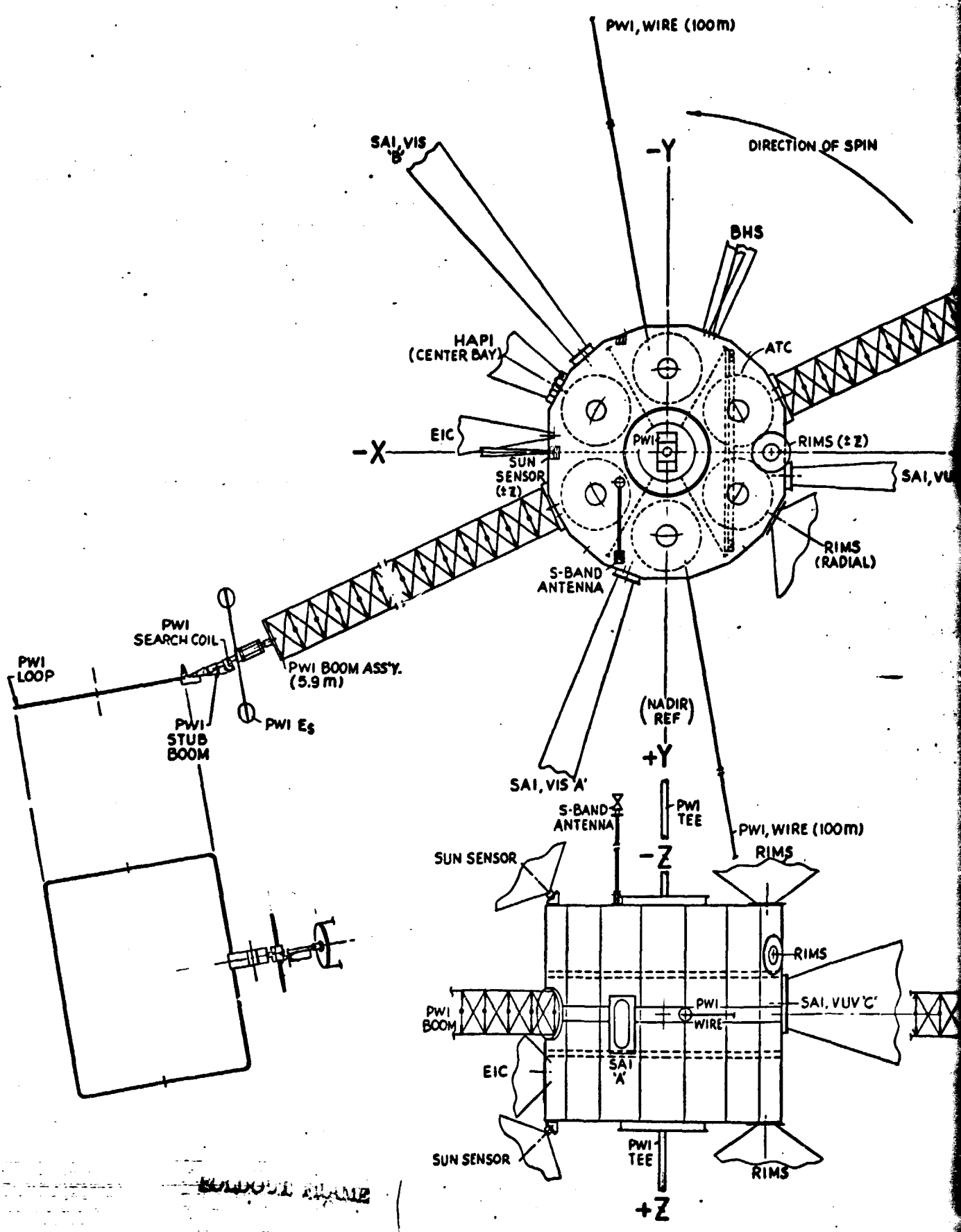
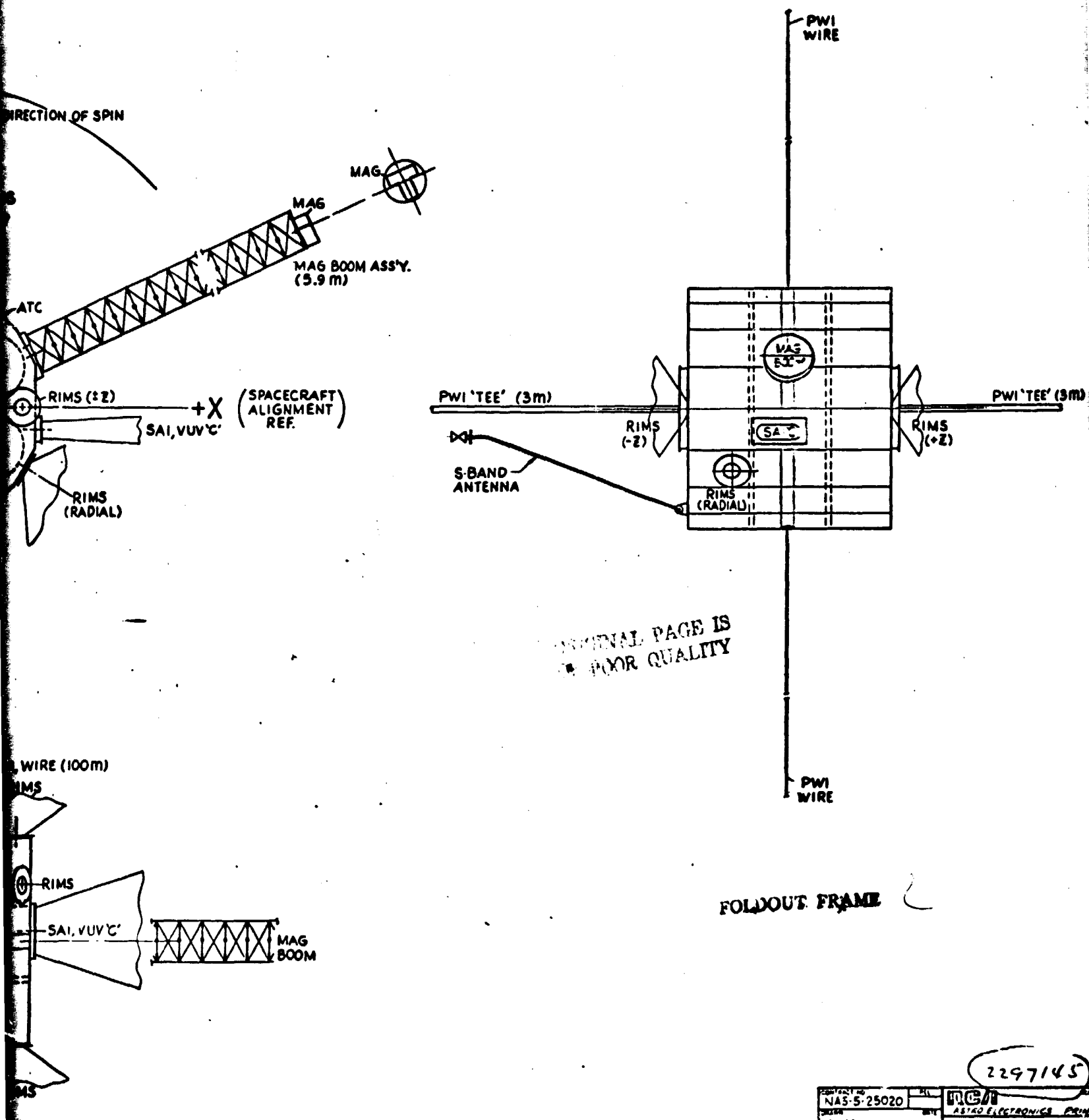

PWI, WIRE (100m)
SAI, VIS 'B'
-Y
DIRECTION OF SPIN
BHS
HAPI (CENTER BAY)
ATC
EIC
-X
PWI
RIMS (±Z)
SUN SENSOR (±Z)
SAI, VU
RIMS (RADIAL)
S-BAND ANTENNA
PWI SEARCH COIL
PWI LOOP
PWI BOOM ASS'Y. (5.9m)
PWI STUB BOOM
PWI Es
(NADIR) REF
+Y
SAI, VIS 'A'
S-BAND ANTENNA
PWI TEE
PWI, WIRE (100m)
SUN SENSOR
-Z
RIMS
RIMS
PWI BOOM
PWI WIRE
SAI, VUV 'C'
EIC
SAI 'A'
SUN SENSOR
PWI TEE
RIMS
+Z

FIG. 7

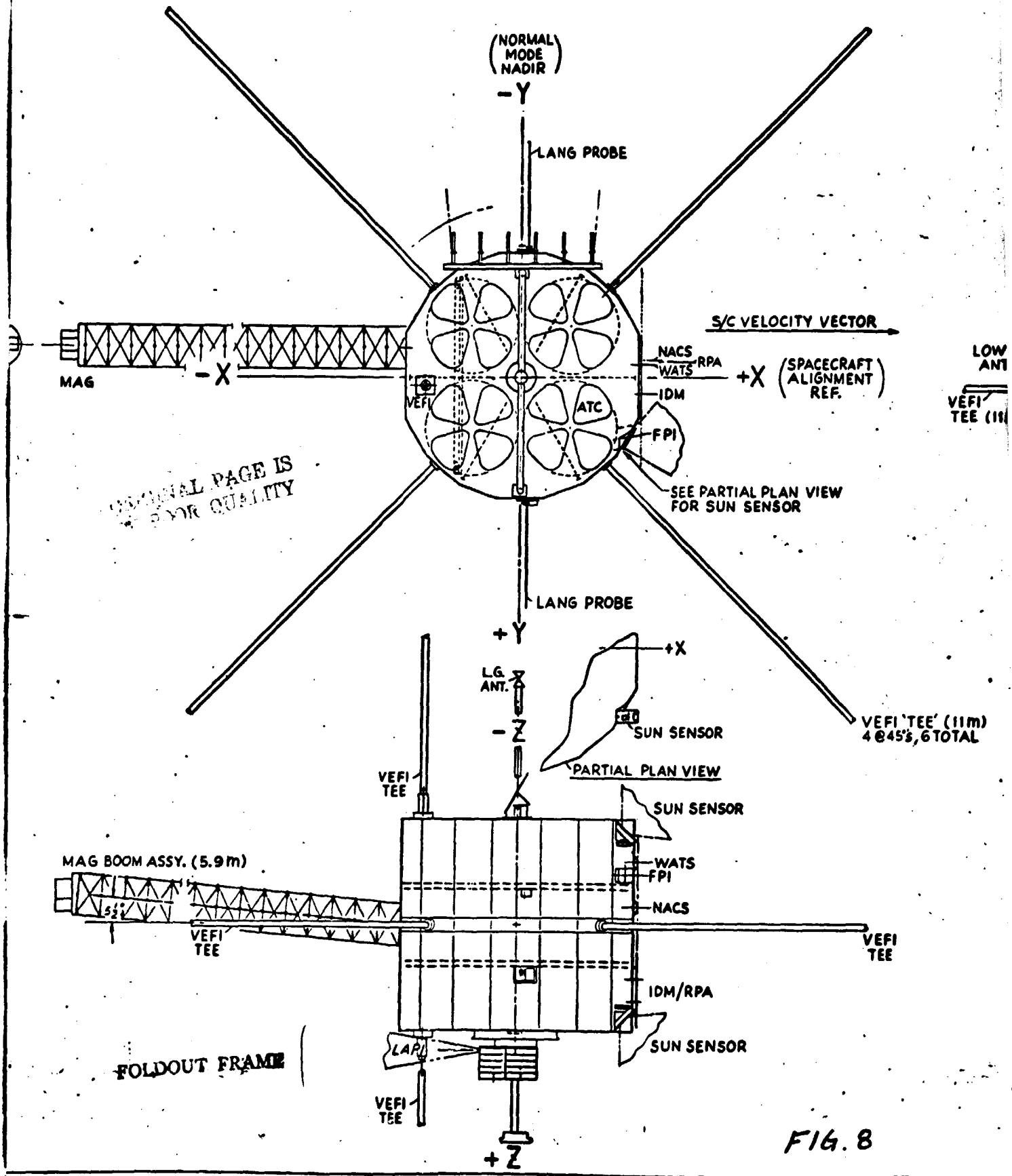


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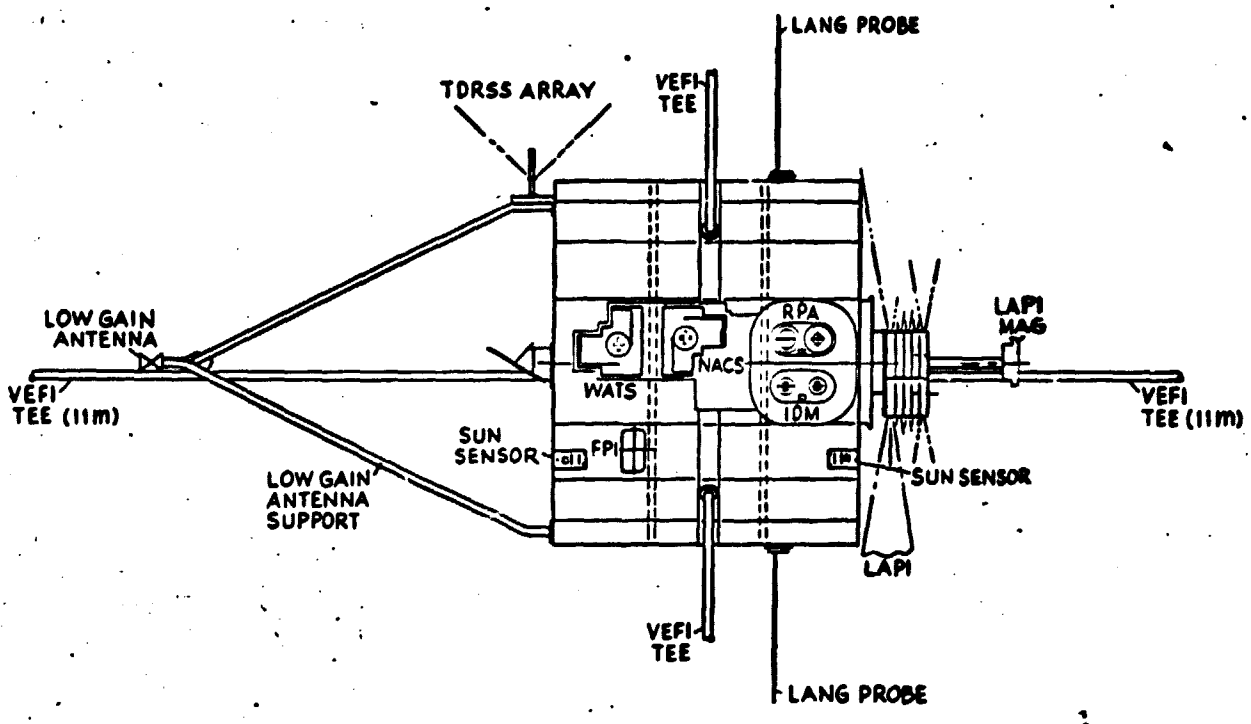
CONTRACT NO. NAS-5-25020	RCA ASTRO ELECTRONICS PRINCETON	
DESIGN J A MASIARZ 6-1-70	ORBITAL CONFIGURATION DE-A	
DRAWN		
APPROVED	SIZE E	COMP. IDENT NO. 49671
SCALE 1/10		22971



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FIG. 8



VEFI 'TEE' (11m)
4 @ 45's, 6 TOTAL

VEFI TEE

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CONTRACT NO NAS-5-25020	RCA ASTRO ELECTRONICS PRINCETON, N.J.	
J. A. MASSAR	ORBITAL CONFIGURATION DE-B	
	E 49671	2297144

8

APPENDIX A

DE-A STOWED MASS PROPERTIES

COMPUTER OUTPUT

DYNAMICS EXPLORER DE-A
SPACECRAFT CONFIGURATION REPORT SYSTEM
01 OCTOBER 1978 STAGE

ID	DATE	NAME	DRWG.NO.	SOURCE	ZONE	PROPOSAL WEIGHT	TARGET WEIGHT	EST/ACT WEIGHT	%TOL	WT TOL	QTY
1 [illegible]	11 1 7	[illegible]-A	2-45[illegible]-501		1.	[illegible].0	0.0	0.0	0.0	0.0	1.
1 [illegible]	[illegible] 1 [illegible]	STRUCTURE-A=			1.	158.90	180.20	0.0	0.0	0.0	1.
1 101.2	11 1 7	UPPER SP		AE-C	1.	0.0	0.0	23.400	0.0	0.0	1.
1 102[illegible]	11 1 7	L[illegible] SP			1.	[illegible].0	0.0	22.800	0.0	0.0	1.
1 1[illegible]	11 1 7	[illegible] CYL/SH P			1.	0.1	0.0	0.0	0.0	0.0	1.
1 10301	11 1 7	[illegible]TEL CYL			1.	0.0	0.0	9.200	0.0	0.0	1.
1 10[illegible]	11 1 7	SHR PANEL 1			1.	0.0	0.0	2.420	0.0	0.0	1.
1 10[illegible]	11 1 7	SHR PANEL 2			1.	0.0	0.0	2.420	0.0	0.0	1.
1 10[illegible]	11 1 7	SHR PANEL 3			1.	0.0	0.0	2.420	0.0	0.0	1.
1 10305	11 1 7	SHR PANEL 4			1.	0.0	0.0	2.420	0.0	0.0	1.
1 10[illegible]	11 1 7	SHR PANEL 5			1.	0.0	0.0	2.420	0.0	0.0	1.
1 10307	11 1 7	SHR PANEL 6			1.	0.0	0.0	2.420	0.0	0.0	1.
1 [illegible]	11 1 7	SEP NUT UPR			1.	0.0	0.0	15.300	0.0	0.0	1.
1 [illegible]	[illegible] 1 [illegible]	SEP NUT LWR			1.	0.0	0.0	15.300	0.0	0.0	1.
1 10[illegible]	M 1 A	HAT UPPER			1.	0.0	0.0	0.0	0.0	0.0	1.
1 10[illegible]	[illegible] 1 A	[illegible]GES PU			1.	0.0	0.0	15.700	0.0	0.0	1.
1 [illegible]	11 1 A	[illegible] MT			1.	0.0	0.0	0.350	0.0	0.0	1.
1 107	1 A	HAT LOWER			1.	0.0	0.0	0.0	0.0	0.0	1.
1 10707[illegible]	M 1 A	SI ES PL			1.	0.0	0.0	15.700	0.0	0.0	1.
1 107 [illegible]	[illegible] 1 [illegible]	[illegible] ML			1.	0.0	0.0	0.350	0.0	0.0	1.
1 [illegible]	S 1	CENTER RING			1.	0.0	0.0	0.0	0.0	0.0	1.
1 [illegible]	S 1	RING			1.	0.0	0.0	0.500	0.0	0.0	1.
1 [illegible]	S 1	BRACKETS			1.	0.0	0.0	0.600	0.0	0.0	1.
1 1110	11 1 7	HARDWARE			1.	0.0	0.0	1.000	0.0	0.0	1.
1 1111	11 1 7	MISC			1.	0.0	0.0	2.500	0.0	0.0	1.
1 [illegible]	11 1 7	[illegible]CALS			1.	0.0	0.0	0.300	0.0	0.0	1.
1 11309	11 1 7	LEXTRA HDWR			1.	0.0	0.0	0.700	0.0	0.0	1.
1 111	M 1 A	RF SCANS			1.	0.0	0.0	0.0	0.0	0.0	1.
1 [illegible]	S 1 A	RF SCANS UPR			1.	0.0	0.0	0.178	0.0	0.0	6.
1 [illegible]	S 1 A	RF SCANS LWR			1.	0.0	0.0	0.178	0.0	0.0	6.
1 [illegible]	11 1 7	HINGE-BODY			1.	0.0	0.0	2.000	0.0	0.0	1.
1 [illegible]	[illegible] 1 [illegible]	ANTENNA SUCT			1.	0.0	0.0	0.0	0.0	0.0	1.
1 [illegible]501	1 1 A	HINGE MECH			1.	0.0	0.0	1.500	0.0	0.0	1.
1 11[illegible]	1 1 A	LAUNCH SUPT			1.	0.0	0.0	1.500	0.0	0.0	1.
1 [illegible]	[illegible] 1 [illegible]	RELEASE HDWR			1.	0.0	0.0	1.000	0.0	0.0	1.
1 1170	M 1 A	ATC BRACKETS			1.	0.0	0.0	0.335	0.0	0.0	6.
1 [illegible]600	[illegible] 1 A	ATC BRACKETS			1.	0.0	0.0	0.335	0.0	0.0	6.
1 [illegible]	S 1 A	[illegible] [illegible]			1.	10.00	12.10	0.0	0.0	0.0	1.
1 [illegible]	11 1 7	TH-UPR MAT			1.	0.0	0.0	0.0	0.0	0.0	1.
1 [illegible]	[illegible] 1 A	TH-LWR MAT			1.	0.0	0.0	3.750	0.0	0.0	1.
1 [illegible]	M 1 A	ATC-UPR MAT			1.	0.0	0.0	0.335	0.0	0.0	6.
1 [illegible]	11 1 7	TH-LWR MAT			1.	0.0	0.0	0.0	0.0	0.0	1.
1 [illegible]	11 1 7	TH-LWR MAT			1.	0.0	0.0	3.750	0.0	0.0	1.
1 [illegible]	M 1 A	ATC-LWR MAT			1.	0.0	0.0	0.335	0.0	0.0	6.
1 [illegible]	11 1 7	TH-UPR SUP			1.	0.0	0.0	0.0	0.0	0.0	1.
1 [illegible]	M 1 A	T MP SENS-UB			1.	0.0	0.0	0.240	0.0	0.0	1.
1 [illegible]	11 1 7	TH-LWR SUP			1.	0.0	0.0	0.0	0.0	0.0	1.
1 [illegible]	M 1 A	TEMP SENS-LB			1.	0.0	0.0	0.240	0.0	0.0	1.
1 [illegible]	11 1 7	TH HEATERS			1.	0.0	0.0	0.100	0.0	0.0	1.
1 [illegible]	11 1 7	ATT CONTR A			1.	62.00	62.00	0.0	0.0	0.0	1.

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1030130	11 1 7	RDY HOR SENS			1.	0.0	0.0	3.000	0.0	0.0	1.
1030313	8 1 5	SUI SENSOR			1.	0.0	0.0	0.0	0.0	0.0	1.
1030321	8 1 3	ELECTRONICS			1.	0.0	0.0	1.300	0.0	0.0	1.
1030302	8 1 8	DETECTOR			1.	0.0	0.0	0.500	0.0	0.0	2.
1030400	11 1 7	NUT DPM+COIL			1.	1.0	0.0	0.0	0.0	0.0	1.
1030401	8 1 8	NUT DAMPER			1.	0.0	0.0	13.000	0.0	0.0	1.
1030402	8 1 8	ATT COIL			1.	1.0	0.0	6.000	0.0	0.0	2.
1030[illegible]	8 1 8	MOUNT COIL			1.	0.0	0.0	31.000	0.0	0.0	1.
1030603	8 1 8	PITCH DAMPER			1.	0.0	0.0	13.000	0.0	0.0	1.
1040[illegible]	5 1 7	POWER			1.	120.10	127.10	0.0	0.0	0.0	1.
1040101	11 1 7	UPPER SOL AR	2294444-501		1.	0.0	0.0	0.0	0.0	0.0	1.
1040101	10 1 [illegible]	CELL MODULES			1.	0.0	0.0	24.440	0.0	0.0	1.
1040102	10 1 7	SHUNT WIRING			1.	0.0	0.0	3.100	0.0	0.0	1.
1040103	10 1 [illegible]	AT DEP			1.	0.0	0.0	1.700	0.0	0.0	1.
1040200	11 1 7	LOWER SOL AR	2294744-501		1.	0.0	0.0	0.0	0.0	0.0	1.
1040201	10 1 [illegible]	CELL MODULES			1.	0.0	0.0	24.580	0.0	0.0	1.
1040202	10 1 [illegible]	SHUNT WIRING			1.	0.0	0.0	3.100	0.0	0.0	1.
1040203	10 1 [illegible]	[illegible]			1.	0.0	0.0	1.600	0.0	0.0	1.
1040300	11 1 7	BATTERIES			1.	0.0	0.0	0.0	0.0	0.0	1.
1040301	3 1 [illegible]	BATT 1	2294442-501		1.	0.0	0.0	21.700	0.0	0.0	1.
1040302	3 1 [illegible]	BATT 2	2294442-501		1.	0.0	0.0	21.700	0.0	0.0	1.
1040400	11 1 7	PWR SUPL EL	2294540-501		1.	0.0	0.0	22.500	0.0	0.0	1.
1040[illegible]	[illegible] 1 8	[illegible] A			1.	1[illegible]	18.50	0.0	0.0	0.0	1.
1040[illegible]	3 1 [illegible]	[illegible]	2295146-1		1.	0.0	0.0	7.400	0.0	0.0	1.
1050300	11 1 [illegible]	[illegible] CABLE			1.	0.0	0.0	2.300	0.0	0.0	1.
1050400	10 1 [illegible]	[illegible] ANT.38			1.	0.0	0.0	1.400	0.0	0.0	1.
1050500	10 1 8	ALT MAST.SU			1.	0.0	0.0	1.000	0.0	0.0	1.
1050[illegible]	11 1 7	[illegible] STORA			1.	0.0	0.0	1.800	0.0	0.0	1.
1050800	11 1 7	[illegible] MOD PROC			1.	0.0	0.0	4.400	0.0	0.0	1.
1060[illegible]	5 1 6	[illegible]			1.	53.10	62.3[illegible]	0.0	0.0	0.0	1.
1060100	11 1 7	[illegible]	22945[illegible]-501		1.	0.0	0.0	9.100	0.0	0.0	1.
1060200	11 1 7	[illegible]	2294673-501		1.	0.0	0.0	16.000	0.0	0.0	1.
1060300	11 1 7	RT[illegible]	2294671-501		1.	0.0	0.0	5.400	0.0	0.0	1.
1060400	8 1 8	TAPE RECORDR	2295174	4.16.5-2	1.	0.0	0.0	0.0	0.0	0.0	1.
1060401	8 1 8	TR [illegible]			1.	0.0	0.0	17.000	0.0	0.0	1.
1060402	6 1 6	TR [illegible]			1.	0.0	0.0	17.000	0.0	0.0	1.
1080000	11 1 7	S/C HARNESS	2295147-501		1.	64.70	64.70	0.0	0.0	0.0	1.
1080100	11 1 7	UPPER HARN	2294647-501		1.	0.0	0.0	27.500	0.0	0.0	1.
1080200	11 1 7	LOWER HARN	2294747-501		1.	0.0	0.0	27.500	0.0	0.0	1.
1080300	11 1 7	GROUND BLOCK			1.	0.0	0.0	0.000	0.0	0.0	1.
1080400	11 1 7	GROUND BLOCK			1.	0.0	0.0	0.300	0.0	0.0	1.
1080500	11 1 7	POTTING			1.	0.0	0.0	1.300	0.0	0.0	1.
1080600	11 1 7	CLAMPS			1.	0.0	0.0	1.000	0.0	0.0	1.
1080700	11 1 7	HAT			1.	0.0	0.0	5.500	0.0	0.0	1.
1080800	11 1 7	BRAID STRAP			1.	0.0	0.0	1.500	0.0	0.0	1.
1090000	5 1 [illegible]	[illegible] DE-A			2.	149.29	0.0	0.0	0.0	0.0	1.
1090100	5 1 [illegible]	[illegible]			2.	0.0	7.10	0.0	0.0	0.0	1.
1090101	5 1 8	SENSOR			2.	0.0	0.0	1.610	0.0	0.0	1.
1090102	10 1 8	ELECTRONICS			2.	0.0	0.0	7.032	0.0	0.0	1.
1090103	8 1 [illegible]	THRML ELMNT			2.	0.0	0.0	0.0	0.0	0.0	1.
1090200	5 1 8	[illegible]	2295125-1		2.	0.0	28.53	0.0	0.0	0.0	1.
1090201	5 1 8	PREAMPS			2.	0.0	0.0	0.330	0.0	0.0	4.
1090202	5 1 8	ELECTRONICS			2.	0.0	0.0	21.350	0.0	0.0	1.
1090204	10 1 8	SHORT EL ANT			2.	0.0	0.0	0.150	0.0	0.0	1.
1090205	10 1 8	SH EL ANT EL			2.	0.0	0.0	0.420	0.0	0.0	1.
1090206	10 1 8	SEARCH COIL			2.	0.0	0.0	0.300	0.0	0.0	1.
1090207	10 1 8	SRCH COIL EL			2.	0.0	0.0	0.320	0.0	0.0	1.
1090208	10 1 8	LOOP ANTENNA			2.	0.0	0.0	0.470	0.0	0.0	2.
1090209	10 1 8	LOOP ANTENNA			2.	0.0	0.0	0.680	0.0	0.0	2.
1090300	5 1 8	SAI			2.	0.0	38.00	0.0	0.0	0.0	1.

1996311	10	1	A	VIS SENSOR	2295121-2	2.	0.0	0.0	11.336	0.0	0.0	2.
1990302	10	1	A	VUV SENSOR	2295121-3	2.	0.0	0.0	11.336	0.0	0.0	1.
1996	10	1	A	VIS COVER		2.	0.0	0.0	0.884	0.0	0.0	2.
1990	10	1	A	VUV COVER		2.	0.0	0.0	0.404	0.0	0.0	1.
1990	10	1	A	[illegible]		2.	0.0	0.0	1.800	0.0	0.0	1.
1996800	5	1	A	MAST	2295128-1	2.	0.0	22.00	0.0	0.0	0.0	1.
1 990	5	1	A	ELECTRONICS		2.	0.0	0.0	8.000	0.0	0.0	1.
1 990	5	1	A	[illegible]		2.	0.0	0.0	7.000	0.0	0.0	1.
1 990	5	1	A	[illegible]		2.	0.0	0.0	1.500	0.0	0.0	1.
1 990	5	1	A	[illegible]		2.	0.0	0.0	3.000	0.0	0.0	1.
1 990	5	1	A	R [illegible] SHLD		2.	0.0	0.0	1.000	0.0	0.0	1.
1 990	9	1	A	[illegible]		2.	0.0	0.0	0.500	0.0	0.0	1.
1990530	5	1	A	MIMS		2.	0.0	14.50	0.0	0.0	0.0	1.
1 990	5	1	A	ELECTRONICS	2295125-1	2.	0.0	0.0	6.000	0.0	0.0	1.
1 990	5	1	A	SENSOR	2295125-2	2.	0.0	0.0	7.500	0.0	0.0	1.
1 990	5	1	A	[illegible]	2295121-1	2.	0.0	18.40	18.400	0.0	0.0	1.
1990	10	1	A	[illegible]		2.	0.0	8.00	0.0	0.0	0.0	1.
1 990	10	1	A	[illegible]		2.	0.0	0.0	0.400	0.0	0.0	2.
1990	10	1	A	[illegible]		2.	0.0	0.0	7.720	0.0	0.0	2.
1990	10	1	A	[illegible]		2.	0.0	5.00	0.0	0.0	0.0	1.
1990	10	1	A	[illegible]		2.	0.0	0.0	0.106	0.0	0.0	2.
1990	10	1	A	OUTBD WING		2.	0.0	0.0	0.050	0.0	0.0	2.
1 990	10	1	A	[illegible]		2.	0.0	0.0	0.013	0.0	0.0	2.
1 990	10	1	A	[illegible]		2.	0.0	0.0	0.277	0.0	0.0	2.
1990	10	1	A	[illegible]		2.	0.0	0.0	0.0	0.0	0.0	1.
1990	10	1	A	P.I ASSY		2.	0.0	0.0	0.900	0.0	0.0	1.
1990	10	1	A	P.I MIRR		2.	0.0	0.0	1.100	0.0	0.0	1.
1990	5	1	A	[illegible]		3.	25.00	50.00	0.0	0.0	0.0	1.
1990	10	1	A	SPACECRAFT		3.	0.0	0.0	42.350	0.0	0.0	1.
1990	10	1	A	[illegible]		3.	0.0	0.0	7.600	0.0	0.0	1.
1990	5	1	A	SUNSHIELD		1.	0.0	45.00	0.0	0.0	0.0	1.
1990	10	1	A	[illegible]		1.	0.0	0.0	0.0	0.0	0.0	1.
1990	10	1	A	[illegible]		1.	0.0	0.0	3.320	0.0	0.0	1.
1990102	10	1	A	ASTRO MAIN		1.	0.0	0.0	11.680	0.0	0.0	1.
1990	10	1	A	[illegible]		1.	0.0	0.0	0.0	0.0	0.0	1.
1990	10	1	A	MAST		1.	0.0	0.0	3.320	0.0	0.0	1.
1990	10	1	A	ASTRO MAIN		1.	0.0	0.0	11.680	0.0	0.0	1.
1990	10	1	A	HARNESS		1.	0.0	0.0	0.500	0.0	0.0	1.
1990	10	1	A	HARNESS-MAG		1.	0.0	0.0	1.600	0.0	0.0	1.
1990	5	1	A	ETC REVISION		1.	0.0	0.0	0.0	0.0	0.0	1.

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DYNAMICS EXPLORER DE-A
WEIGHT SUMMARY BY LEVELS
1 OCTOBER 1978

ID	NAME	PROPOSAL WEIGHT		CURRENT TARGET WEIGHT	CURRENT ESTIMATED ACT WT	QTY	DRWNG NO	SOURCE
[illegible]	DE-A	[illegible]	◆	765.00	791.82	1.	[illegible]	
[illegible]	STRUCTURE-A-	134.70	◆	180.20	174.176	1.		
[illegible]	[illegible]	0.0		0.0	23.40	1.		AL-C
[illegible]	[illegible]	0.		0.	22.869	1.		
[illegible]	[illegible]	0.	◆	0.	23.79	1.		
[illegible]	[illegible]	0.		0.	9.20	1.		
[illegible]	[illegible]	0.0		0.0	2.42	1.		
[illegible]	[illegible]	0.0		0.0	2.42	1.		
[illegible]	[illegible]	0.0		0.0	2.42	1.		
[illegible]	[illegible]	0.0		0.0	2.42	1.		
[illegible]	[illegible]	0.0		0.0	2.42	1.		
[illegible]	[illegible]	0.		0.	2.42	1.		
[illegible]	[illegible]	0.0		0.0	15.366	1.		
[illegible]	[illegible]	0.0		0.0	16.35	1.		
[illegible]	HAT UPPER	0.0	◆	0.0	20.859	1.		
[illegible]	[illegible]	0.0		0.0	3.70	1.		
[illegible]	[illegible]	0.0		0.0	4.35	1.		
[illegible]	HAT LOWER	0.0	◆	0.0	20.05	1.		
[illegible]	[illegible]	0.0		0.0	15.786	1.		
[illegible]	[illegible]	0.0		0.0	4.35	1.		
[illegible]	[illegible]	0.0	◆	0.0	14.000	1.		
[illegible]	[illegible]	0.0		0.0	4.500	1.		
[illegible]	BRACKETS	0.0		0.0	9.50	1.		
[illegible]	HARDWARE	0.0		0.0	1.000	1.		
[illegible]	[illegible]	0.0		0.0	2.500	1.		
1011200	COVERS-SEALS	0.0		0.0	4.200	1.		
[illegible]	LIFTING HOOK	0.0		0.0	0.780	1.		
[illegible]	RF SCRNS	0.0	◆	0.0	2.13	1.		
[illegible]	RF SCRNS UPR	0.0		0.0	1.06	6.		
1011402	RF SCRNS LWR	0.0		0.0	1.06	6.		
[illegible]	[illegible]	0.0		0.0	2.080	1.		
[illegible]	S/C MNA SUPT	0.0	◆	0.0	4.000	1.		
[illegible]	[illegible]	0.0		0.0	1.50	1.		
[illegible]	[illegible]	0.0		0.0	1.560	1.		
[illegible]	[illegible]	0.0		0.0	1.000	1.		
[illegible]	ATC BRACKETS	0.0		0.0	2.91	6.		
[illegible]	ATC BRACKETS	0.0		0.0	2.01	6.		
1027000	THERMAL -A-	12.00	◆	12.10	12.07	1.		
[illegible]	THR-UPR HAT	0.0	◆	0.0	5.74	1.		
[illegible]	THR-UPR HAT	0.0		0.0	3.75	1.		
[illegible]	ATC-U R HAT	0.0		0.0	1.999	6.		
1027200	THR-LWR HAT	0.0	◆	0.0	5.74	1.		
[illegible]	THR-LWR HAT	0.0		0.0	3.75	1.		
[illegible]	ATC-L R HAT	0.0		0.0	1.999	6.		
1027300	THR-UPR B/P	0.0	◆	0.0	0.240	1.		
[illegible]	TEMP SENS-UR	0.0		0.0	0.296	1.		
1027400	THR-LWR B/P	0.0	◆	0.0	0.240	1.		
1027401	TEMP SENS-LR	0.0		0.0	0.240	1.		
1027500	TH HEATERS	0.0		0.0	0.180	1.		

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1030806	ATT CONTR A	62.70	◆	62.90	74.380	1.		
1030178	BDY MOD SENS	0.0		0.0	3.600	1.		
1030300	RMN SENSOR	0.0	◆	0.0	2.300	1.		
1030351	ELECTRONICS	0.0		0.0	1.300	1.		
1030302	DETECTOR	0.0		0.0	1.000	2.		
1030868	NUT DRIVE COIL	0.0	◆	0.0	26.000	1.		
1031401	NUT DAMPER	0.0		0.0	13.000	1.		
1031402	ATT COIL	0.0		0.0	12.000	2.		
1030564	MONEAT COIL	0.0		0.0	31.000	1.		
1031600	PITCH DAMPER	0.0		0.0	13.000	1.		
1040000	POWER	120.10	◆	127.10	123.560	1.		
1040100	WIRE HARN AR	0.0	◆	0.0	28.780	1.	3284644-501	
1040101	CELL MODULES	0.0		0.0	24.680	1.		
1040102	SHUNT WIRING	0.0		0.0	3.100	1.		
1040103	DIODES	0.0		0.0	1.000	1.		
1040200	LOWER SOL AR	0.0	◆	0.0	28.780	1.	2294744-501	
1040201	CELL MODULES	0.0		0.0	24.680	1.		
1040202	SHUNT WIRING	0.0		0.0	3.100	1.		
1040203	DIODES	0.0		0.0	1.000	1.		
1040300	BATTERIES	0.0	◆	0.0	43.400	1.	3284643-501	
1040301	BATT 1	0.0		0.0	21.700	1.	2294642-501	
1040302	BATT 2	0.0		0.0	21.700	1.	2294640-501	
1040400	PWR SUPL EL	0.		0.0	22.600	1.		
1040500	CONNCTNG A	16.70	◆	18.50	18.560	1.		
1050200	NO-NST XMNR	0.0		0.0	7.600	1.	2295160-1	
1050300	RCONDR CABLE	0.0		0.0	2.300	1.		
1050400	NO AR ANT+SD	0.0		0.0	1.000	1.		
1050500	ANT MAST+SH	0.0		0.0	1.000	1.		
1050600	SHELT NTWRK	0.0		0.0	1.800	1.		
1050800	PR MOD ERGC	0.0		0.0	4.400	1.		
1060000	C & DH	53.10	◆	62.30	62.300	1.		
1060100	CTC	0.0		0.0	9.100	1.	2294670-501	
1060200	COU	0.0		0.0	10.800	1.	3284671-501	
1060300	RTU	0.0		0.0	8.400	1.	2294671-501	
1060400	TAPE RECORDR	0.0	◆	0.0	30.000	1.	2295174	4.16.5-2
1060401	TR ASSEMBLY	0.0		0.0	17.000	1.		
1060402	TR RCRDR	0.0		0.0	17.000	1.		
1060700	S/C HARNESS	64.70	◆	64.70	64.700	1.	2295147-501	
1061100	UPPER HARN	0.0		0.0	27.500	1.	3284647-501	
1061200	LOWER HARN	0.0		0.0	27.500	1.	2294747-501	
1061300	GROUND BLOCK	0.0		0.0	0.400	1.		
1061400	GROUND BLOCK	0.0		0.0	0.300	1.		
1060500	POTTING	0.0		0.0	1.000	1.		
1060600	CLAMPS	0.0		0.0	1.000	1.		
1060700	MAT	0.0		0.0	0.500	1.		
1060800	GRID STRAP	0.0		0.0	1.500	1.		
1060900	GPL UL-A	149.29	◆	142.20	172.122	1.		
1060100	MAG	0.0	◆	7.10	8.642	1.		
1060101	SENSOR	0.0		0.0	1.610	1.		
1060102	ELECTRONICS	0.0		0.0	7.032	1.		
1060103	THERM BLNKT	0.0		0.0	0.0	1.		
1060200	ANT	0.0	◆	28.50	26.960	1.	2295125-1	
1060201	PREAMPS	0.0		0.0	1.320	4.		
1060202	ELECTRONICS	0.0		0.0	21.360	1.		
1060204	SHORT EL ANT	0.0		0.0	0.150	1.		
1060205	SH EL ANT EL	0.0		0.0	0.429	1.		
1060206	SEARCH COIL	0.0		0.0	0.380	1.		
1060207	SRCH COIL EL	0.0		0.0	0.320	1.		
1060208	LOOP ANTENNA	0.0		0.0	1.740	2.		
1060209	LOOP ANTENNA	0.0		0.0	1.360	2.		

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1[illegible]300	SAT	0.0	*	38.00	38.220	1.	
1[illegible]301	VIS [illegible]	0.0		0.0	22.672	2.	2295121-2
1[illegible]302	[illegible]	0.0		0.0	11.336	1.	[illegible]
1[illegible]303	VIS COVER	0.0		0.0	1.602	2.	
1[illegible]304	UUV COVER	0.0		0.0	0.804	1.	
1[illegible]305	[illegible]	0.0		0.0	1.606	1.	
1[illegible]400	[illegible]	0.0	*	22.00	22.[illegible]	1.	2295120-1
1[illegible]401	ELECTRONICS	0.0		0.0	9.300	1.	
1[illegible]402	DET ASSY	0.0		0.0	7.000	1.	
1[illegible]403	[illegible]	0.0		0.0	1.50	1.	
1[illegible]404	[illegible]	0.0		0.0	2.600	1.	
1[illegible]405	RAD SHLD	0.0		0.0	1.606	1.	
1[illegible]406	CABLING	0.0		0.0	0.500	1.	
1[illegible]501	RIMS	0.0	*	14.50	24.500	1.	
1[illegible]561	ELECTRONICS	0.0		0.0	6.000	1.	[illegible]
1[illegible]562	[illegible]	0.0		0.0	22.500	3.	2295123-2
1[illegible]601	EIC	0.0		18.40	18.400	1.	2295121-1
1[illegible]706	TUBULAR 1.13	0.0	*	6.20	14.400	1.	
1[illegible]771	TUBE ANTENNA	0.0		0.0	0.900	2.	
1[illegible]772	DISPENSER	0.0		0.0	15.440	2.	
1[illegible]850	PNT WIRE 350	0.0	*	5.50	11.000	1.	
1[illegible]851	INNER WIRE	0.0		0.0	0.320	2.	
1[illegible]852	OUTER WIRE	0.0		0.0	0.150	2.	
1[illegible]853	TIP MASS	0.0		0.0	0.020	2.	
1[illegible]854	DISPENSER	0.0		0.0	10.554	2.	
1[illegible]975	BOOMS	0.0	*	2.0	2.000	1.	
1[illegible]981	PNT SUB-ASSY	0.0		0.0	0.500	1.	
1[illegible]	[illegible] WIRE	0.0		0.0	1.100	1.	
1[illegible]	BALANCE -A-	25.00	*	50.00	50.[illegible]	1.	
1100100	S/C BALANCE	0.0		0.0	62.350	1.	
1[illegible]205	[illegible]AL	0.0		0.0	7.650	1.	
1[illegible]	SUPT -GUI-	0.0	*	45.00	34.[illegible]	1.	
1[illegible]100	ASTRONST-MAG	0.0	*	0.0	14.040	1.	
1[illegible]1	[illegible]	0.0		0.0	2.320	1.	
1[illegible]	[illegible]	0.0		0.0	11.680	1.	
1[illegible]200	ASTRONST-MAG	0.0	*	0.0	14.600	1.	
1[illegible]1	MAST	0.0		0.0	2.321	1.	
1300202	ASTRO HOUR	0.0		0.0	11.680	1.	
1[illegible]306	HARNESS-PRI	0.0		0.0	6.580	1.	
1300400	HARNESS-MAG	0.0		0.0	1.600	1.	
1400600	EMC REVISION	0.0		0.0	0.0	1.	

DYNAMICS EXPLORER DE-A
ZONE AND PHASE SUMMARY
01 OCTOBER 1978

ZONE	PROPOSAL WEIGHT	CURRENT TARGET WEIGHT	CURRENT ESTIMATED WEIGHT
1	[illegible]	[illegible]	[illegible]
2	149.29	142.20	172.122
3	25.00	50.00	50.000

PHASE	PROPOSAL WT	CURRENT TARGET WT	CURRENT ESTIMACT WT
TOTAL SYSTEM LAUNCH WEIGHT INCL BAL WT	638.68	765.06	791.031
SPACECRAFT HARDWARE WEIGHT INCL BAL	[illegible]	[illegible]	[illegible]
GFE INSTRUMENTATION WEIGHT	149.29	142.20	172.122
TOTAL BALANCE WEIGHT	25.00	50.00	50.000

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DYNAMICS EXPLORER DE-A
INPUT MOMENT OF INERTIA AND C.G. INFORMATION
01 OCTOBER 1978

NOMENCLATURE	I.D.NO.	TP	NO	PA	IX/IXX	IY/IYY	IZ/IZZ	RAD-0	RAD-1	XBAR	YBAR	ZBAR	WEIGHT
UPPER HF	1119100	15	1	1	4145.9	4145.9	8291.0	0.0	0.0	0.0	0.0	-6.5	23.40
LOWER HF	1118200	15	1	0	4145.9	4145.9	8291.0	0.0	0.0	0.0	0.0	6.5	23.40
CENTER CYL	1118301	15	1	1	468.3	468.3	554.3	0.0	0.0	0.0	0.0	0.0	9.23
SHR PANL 1	1218302	1	1	1	17.9	0.1	16.8	0.0	0.0	-15.2	0.0	0.0	2.42
SHR PANL 2	1218303	1	1	0	17.9	0.1	16.8	0.0	0.0	-7.6	-13.6	0.0	2.42
SHR PANL 3	1218304	1	1	1	17.9	0.1	16.8	0.0	0.0	7.6	13.6	0.0	2.42
SHR PANL 4	1218305	1	1	1	17.9	0.1	16.8	0.0	0.0	15.2	0.0	0.0	2.42
SHR PANL 5	1218306	1	1	1	17.9	0.1	16.8	0.0	0.0	7.6	-13.6	0.0	2.42
SHR PANL 6	1218307	1	1	1	17.9	0.1	16.8	0.0	0.0	-7.6	-13.6	0.0	2.42
SEP ADPT UPR	1219400	15	1	1	1264.7	1264.7	553.5	0.0	0.0	0.0	0.0	-16.6	15.30
SEP ATDT LWR	1219500	15	1	1	1264.7	1264.7	553.5	0.0	0.0	0.0	0.0	16.6	15.30
SIDES MU	1119601	9	1	0	0.0	0.0	28.7	24.0	26.2	0.0	0.0	-22.5	15.70
END MU	1119602	9	1	0	0.0	0.0	8.5	26.2	0.0	0.0	0.0	-22.5	4.35
SIDES ML	1119701	9	1	0	0.0	0.0	28.7	24.0	26.2	0.0	0.0	22.5	15.70
END ML	1119702	9	1	0	0.0	0.0	8.5	26.2	0.0	0.0	0.0	22.5	4.35
CENTER RING	1119800	9	1	0	0.0	0.0	3.7	24.0	26.4	0.0	0.0	0.0	16.88
BRKTS+MISC	1119900	4	1	0	0.0	0.0	45.2	25.1	0.0	0.0	0.0	0.0	0.00
COVERS+SEALS	1119200	4	1	0	0.0	0.0	45.2	25.1	0.0	0.0	0.0	0.0	4.20
LIFTING HDWR	1119300	4	1	0	0.0	0.0	45.2	25.1	0.0	0.0	0.0	0.0	3.70
MOUNTING	1119400	4	1	0	0.0	0.0	45.2	25.1	0.0	0.0	0.0	0.0	0.00
HINGE MECH	1111601	1	1	0	2.0	2.5	2.5	0.0	0.0	-16.0	22.0	-23.0	1.40
LAUNCH SUPPT	1111602	1	1	0	2.0	2.0	1.0	0.0	0.0	-16.0	0.0	-23.0	1.50
RELEASE MECH	1111603	1	1	0	2.0	2.0	1.0	0.0	0.0	-16.0	-22.0	-23.0	1.00
ATC BRACKETS	1111700	4	1	0	0.0	0.0	0.7	1.5	0.0	-16.0	5.5	-20.0	0.33
ATC BRACKETS	1111701	4	1	0	0.0	0.0	0.7	1.5	0.0	-3.5	17.0	-20.0	0.33
ATC BRACKETS	1111702	4	1	0	0.0	0.0	0.7	1.5	0.0	16.0	-6.5	-20.0	0.33
ATC BRACKETS	1111703	4	1	0	0.0	0.0	0.7	1.5	0.0	3.0	-17.5	-20.0	0.33
ATC BRACKETS	1111704	4	1	0	0.0	0.0	0.7	1.5	0.0	-16.0	5.5	20.0	0.33
ATC BRACKETS	1111705	4	1	0	0.0	0.0	0.7	1.5	0.0	-3.5	17.0	20.0	0.33
ATC BRACKETS	1111706	4	1	0	0.0	0.0	0.7	1.5	0.0	16.0	-6.5	20.0	0.33
ATC BRACKETS	1111707	4	1	0	0.0	0.0	0.7	1.5	0.0	3.0	-17.5	20.0	0.33
ATC BRACKETS	1111660	4	1	0	0.0	0.0	0.7	1.5	0.0	-13.0	-11.5	20.0	0.33
THB-UPR MAT	1120101	9	1	0	0.0	0.0	28.7	25.1	24.9	0.0	0.0	-18.4	3.75
ATC-UPR MAT	1120102	4	1	0	0.0	0.0	0.7	7.3	0.0	-16.0	5.5	-20.0	0.33
ATC-UPR MAT	1120103	4	1	0	0.0	0.0	0.7	7.3	0.0	-3.5	17.0	-20.0	0.33
ATC-UPR MAT	1120104	4	1	0	0.0	0.0	0.7	7.3	0.0	13.3	11.0	-20.0	0.33
ATC-UPR MAT	1120105	4	1	0	0.0	0.0	0.7	7.3	0.0	16.0	-6.5	-20.0	0.33
ATC-UPR MAT	1120106	4	1	0	0.0	0.0	0.7	7.3	0.0	3.0	-17.5	-20.0	0.33
ATC-UPR MAT	1120107	4	1	0	0.0	0.0	0.7	7.3	0.0	-13.0	-11.5	-20.0	0.33
THB-LWR MAT	1120201	9	1	0	0.0	0.0	28.9	25.1	24.9	0.0	0.0	18.4	3.75
ATC-LWR MAT	1120202	4	1	0	0.0	0.0	0.7	7.3	0.0	-16.0	5.5	20.0	0.33
ATC-LWR MAT	1120203	4	1	0	0.0	0.0	0.7	7.3	0.0	-3.5	17.0	20.0	0.33
ATC-LWR MAT	1120204	4	1	0	0.0	0.0	0.7	7.3	0.0	13.3	11.0	20.0	0.33
ATC-LWR MAT	1120205	4	1	0	0.0	0.0	0.7	7.3	0.0	16.0	-6.5	20.0	0.33
ATC-LWR MAT	1120206	4	1	0	0.0	0.0	0.7	7.3	0.0	3.0	-17.5	20.0	0.33
TEMP SENS-UB	1020301	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.24
TEMP SENS-LB	1020401	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.24
TH HEATERS	1020501	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10
ROT MOM SENS	1030101	1	1	1	4.5	5.5	3.9	0.0	0.0	7.0	-21.5	-6.5	1.00

DETECTOR	1030302	1	1	0	2.2	2.2	2.2	0.0	0.0	-24.0	0.0	-23.5	0.50
DETECTOR	1030332	1	1	0	2.2	2.2	2.2	0.0	0.0	-24.0	0.0	23.5	0.50
NUT DAMPER	[illegible]	13	1	0	3049.0	5072.7	4013.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ATT COIL	1033032	13	1	0	1956.7	1951.7	3981.5	0.0	0.0	0.0	0.6	7.5	6.00
MOMENT COIL	1033530	13	1	0	12726.5	7473.0	7479.0	0.0	0.6	13.0	0.0	9.0	31.60
PITCH DAMPER	[illegible]	13	1	0	4231.2	4231.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UPPER SOL AR	1040170	13	1	0	19116.6	10116.6	15981.3	0.0	0.0	0.0	0.0	-17.1	20.70
LOWER SOL AP	1040201	13	1	0	19116.6	10116.6	15701.3	0.0	0.0	0.0	0.0	17.1	20.70
BATT 1	1043300	1	1	0	5.5	11.3	4.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BATT 2	1046302	1	1	0	11.3	5.5	4.0	0.0	0.0	-1.0	-20.7	11.1	21.70
PWR SUPL EL	1040401	1	1	0	14.6	7.5	6.6	3.3	0.0	0.6	20.2	-13.1	22.60
NE-BST ASSY	[illegible]	1	1	0	7.0	5.5	3.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XPONDR CABLE	1050330	1	1	0	7.8	5.5	3.5	0.0	0.0	11.8	9.0	10.5	2.30
MD SN ANT.SM	1050430	3	1	0	0.0	5.5	0.0	1.0	0.0	-10.0	-30.0	-25.2	1.40
ANT MAST.SM	[illegible]	11	1	0	6.0	50.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S.-FLT ?ITNK	1051401	1	1	0	7.5	7.0	3.5	0.0	0.0	-4.6	-10.0	10.5	1.80
PRE-OD PROC	1057970	1	1	0	4.7	6.5	3.8	0.1	0.0	-11.5	4.0	12.5	4.40
CIP	1360140	1	1	0	12.3	6.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CDU	1060230	1	1	0	9.2	6.9	8.8	0.0	0.0	-8.7	12.6	13.1	10.72
RTM	1063330	1	1	0	6.9	4.2	6.6	0.0	0.0	1.8	14.2	13.1	8.40
TP ACRDR	[illegible]	1	1	0	13.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TP RCRDR	1060402	1	1	0	13.0	9.0	6.0	0.0	0.0	-15.2	-4.1	-11.8	17.00
S/C HARNESS	1070000	4	1	0	0.0	3.0	45.0	25.0	0.0	0.0	0.0	0.0	64.70
SENSOR	1331141	1	1	1	6.0	6.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ELECTRONICS	1391192	1	1	0	4.5	7.0	7.6	0.0	0.0	7.2	-12.2	11.9	7.03
THRML PLNRT	1331103	1	1	0	4.5	7.0	7.6	0.0	0.0	7.2	-12.2	11.9	0.0
PREAMPS	1333201	1	1	1	1.3	3.0	2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PREAMPS	1393231	1	1	1	1.3	3.0	2.5	0.0	0.0	-1.8	-17.5	0.0	0.33
PREAMPS	1390211	1	1	0	3.8	1.3	2.5	0.0	1.7	0.0	-2.7	-12.9	0.33
PREAMPS	[illegible]	1	1	0	3.0	1.3	2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ELECTRONICS	1390212	1	1	0	12.6	12.0	7.5	0.0	0.0	0.0	-14.9	-12.5	21.35
SHORT EL ANT	1390230	10	1	1	24.0	0.0	0.0	0.1	0.0	-32.0	14.0	0.0	0.15
SH EL ANT #1	[illegible]	1	1	1	1.3	[illegible]	1.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SEARCH COIL	1390296	13	1	0	0.0	3.0	16.0	0.0	0.0	-33.0	17.0	0.0	0.30
SRCH COIL EL	1390297	1	1	1	1.3	1.3	2.0	0.0	0.0	-33.0	17.0	0.0	0.32
LOOP ANTENNA	[illegible]	4	1	0	0.0	3.0	45.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LOOP ANTENNA	1390230	4	1	0	0.0	0.0	45.0	0.4	0.0	0.0	20.0	0.0	0.07
LOOP ANTENNA	1390289	2	1	1	35.0	0.0	0.0	0.4	0.0	-17.0	24.9	22.5	0.60
LOOP ANTENNA	1390230	2	1	1	35.0	3.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VIS SENSOR	1390301	13	1	1	461.0	627.1	555.5	0.0	0.0	-14.2	-13.3	6.4	11.34
VIS SENSOR	1390301	13	1	0	461.0	627.1	555.5	0.0	0.0	18.6	6.3	-6.4	11.34
NUV SENSOR	[illegible]	13	1	1	461.0	627.1	555.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VIS COVER	1390313	11	1	1	0.0	0.0	0.0	3.3	0.0	-8.5	26.6	2.0	0.00
VIS COVER	1390313	11	1	1	0.0	0.0	0.0	3.3	0.0	-12.0	-20.0	2.0	0.00
NUV COVER	1390320	10	1	0	0.0	0.0	0.0	3.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DCU	1393320	1	1	0	3.8	1.8	5.3	0.0	0.0	0.4	8.5	6.1	1.60
ELECTRONICS	1390401	1	1	0	6.3	7.9	5.5	0.0	0.0	-11.6	-14.6	-11.5	9.00
DET ASSY	1390400	1	1	1	6.6	7.5	6.6	3.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HVPS	1390402	1	1	0	6.3	7.9	5.5	0.0	0.0	-11.6	-14.6	-11.5	1.50
FPS	1390404	1	1	0	6.3	7.9	5.5	0.0	0.0	-11.6	-14.6	-11.5	3.00
RAD SHLD	1390400	3	1	1	6.6	7.5	0.0	3.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CABLING	1390496	1	1	0	6.3	7.9	5.5	0.0	0.0	-11.6	-14.6	-11.5	0.50
ELECTRONICS	1390531	1	1	0	5.3	7.6	5.3	0.0	0.0	21.4	-1.5	-11.9	6.00
SENSOR	1390532	1	1	0	5.3	7.0	5.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SENSOR	1390532	1	1	0	5.3	7.8	5.2	0.0	0.0	22.0	-6.8	10.5	7.50
SENSOR	1390532	1	1	1	5.0	7.8	5.3	0.0	0.0	20.1	10.7	-10.8	7.50
EIC	1390600	13	1	0	906.1	448.3	514.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DISPENSER	1390702	13	1	0	193.8	167.3	47.9	0.0	0.0	0.0	0.0	7.2	7.72
DISPENSER	1390702	13	1	0	193.8	167.3	47.9	0.0	0.0	0.0	0.0	-7.2	7.72
INBRD WIRE	1390801	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

INBRD WIRE	1[illegible]	1	1	1	9.8	7.3	5.5	0.0	0.0	6.6	20.0	0.0	0.16
OUTBRD WIRE	1[illegible]	1	1	1	9.8	7.3	5.5	0.0	0.0	-6.6	-20.0	0.0	0.85
OUTBRD WIRE	1[illegible]	1	1	1	9.8	7.3	5.5	0.0	0.0	6.6	20.0	0.0	0.85
TIP MASS	1[illegible]	1	1	1	9.8	7.3	5.5	0.0	0.0	-6.6	-20.0	0.0	0.81
TIP MASS	1[illegible]	1	1	1	9.8	7.3	5.5	0.0	0.0	6.6	20.0	0.0	0.81
DISPERSER	1[illegible]	1	1	1	9.8	7.3	5.5	0.0	0.0	-6.6	-20.0	0.0	0.26
DISPERSER	1790804	1	1	1	9.8	7.3	5.5	0.0	0.0	6.6	20.0	0.0	5.28
PWI SUBASSY	1[illegible]0901	11	1	1	0.0	12.0	0.0	0.5	0.0	-31.0	14.0	0.0	8.[illegible]0
PWI HINGE	1[illegible]	1	1	1	2.0	5.[illegible]	3.0	0.0	0.0	-36.0	15.0	0.0	1.10
S/C BALANCE	11[illegible]	1	1		4.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	42.35
MAG BAL	1[illegible]	2	1	1	5.0	0.5	0.0	4.[illegible]	0.0	24.9	-11.[illegible]	0.0	7.65
MAST	13[illegible]	2	1	1	15.0	0.0	0.0	5.0	0.0	-17.6	8.6	0.0	9.39
ASTRO HDWR	1309132	2	1	1	15.0	0.0	0.0	5.0	0.0	-17.6	8.6	0.0	11.68
MAST	1300[illegible]1	3	1	1	0.0	15.0	0.0	5.0	0.0	17.6	-8.6	0.0	2.32
ASTRO HDWR	1[illegible]	3	1	1	0.0	15.0	0.0	5.0	0.0	17.6	-8.6	0.0	11.68
HARNESS.[illegible]1	1306[illegible]	2	1	1	15.0	0.0	0.0	5.[illegible]	0.0	-17.6	8.6	0.0	6.50
HARNESS.[illegible]	1[illegible]	3	1	1	0.0	15.0	0.0	5.[illegible]	0.0	17.6	-8.6	0.0	1.60

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DYNAMICS EXPLORER DE-A
MOMENT OF INERTIA CALCULATIONS
BOX INERTIA VALUES

NAME	IXX	IYY	IZZ	TYPE
UPPER BP	4145.879	4145.879	8291.0[illegible]	13
LOWER BP	[illegible]	[illegible]	[illegible]	13
CENTER COL	4[illegible]	4[illegible]	354.320	13
SMR PANL 1	[illegible]	121.246	64.330	1
SMR PANL 2	[illegible]	[illegible]	[illegible]	1
SMR PANL 3	56.928	129.032	72.116	1
SMR PANL 4	56.[illegible]	121.534	64.619	1
SMR PANL 5	[illegible]	[illegible]	[illegible]	1
SMR PANL	[illegible]	129.032	72.116	1
SEP ADPT UPR	[illegible]	[illegible]	553.303	13
SEP ADPT LWR	[illegible]	[illegible]	[illegible]	13
SIDES HU	[illegible]	[illegible]	[illegible]	9
END HU	934.[illegible]	934.588	[illegible]	9
SIDES HL	[illegible]	[illegible]	[illegible]	9
END HL	934.[illegible]	934.[illegible]	1660.191	9
CENTER RING	[illegible]	[illegible]	[illegible]	9
HARIS+PISC	[illegible]	[illegible]	[illegible]	4
COVERS+SEALS	1376.[illegible]	1376.574	1323.021	9
LIFTING HOOK	229.429	229.429	221.503	4
HOOKE+BOX	[illegible]	[illegible]	[illegible]	4
MINOR MISC	1.563	1.281	1.281	1
LAUNCH SUPPT	[illegible]	[illegible]	[illegible]	1
RELEASE MECH	[illegible]	[illegible]	[illegible]	1
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	[illegible]	[illegible]	[illegible]	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	[illegible]	[illegible]	[illegible]	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	[illegible]	[illegible]	[illegible]	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	[illegible]	[illegible]	[illegible]	4
THS-UPR MAT	1302.532	1302.532	2332.061	9
ATC-UPR MAT	4.389	4.389	8.752	4
ATC-UPR MAT	[illegible]	[illegible]	[illegible]	4
ATC-UPR MAT	4.389	4.389	8.752	4
ATC-UPR MAT	4.389	4.389	8.752	4
ATC-UPR MAT	[illegible]	[illegible]	[illegible]	4
ATC-UPR MAT	4.389	4.389	8.752	4
THS-LWR MAT	1302.532	1302.532	2332.061	9
ATC-LWR MAT	[illegible]	[illegible]	[illegible]	4
ATC-LWR MAT	4.389	4.389	8.752	4
ATC-LWR MAT	4.389	4.389	8.752	4
ATC-LWR MAT	[illegible]	[illegible]	[illegible]	4
ATC-LWR MAT	4.389	4.389	8.752	4
ATC-LWR MAT	4.389	4.389	8.752	4
TEMP SENS-HB	[illegible]	[illegible]	[illegible]	1
TEMP SENS-LB	0.0	0.0	0.0	1
TH HEATERS	0.0	0.0	0.0	1
ADV MOD SENS	[illegible]	[illegible]	[illegible]	4

DETECTOR	0.403	0.403	0.403	1
DETECTOR	0.403	3.403	0.403	1
NUT DAMPER	[illegible]	5172.689	4512.500	13
ATT COIL	1950.750	1950.750	5501.500	13
MOMENT COIL	12726.410	7473.900	7475.000	13
PITCH DAMPER	8231.139	8231.139	8850.730	13
UPPER SOL AR	10116.602	10116.602	15901.371	13
LOWER SOL AR	10116.602	10116.602	15901.301	13
BATT 1	272.570	96.366	285.608	1
BATT 2	96.366	272.570	285.608	1
PWR SUPL EL	231.763	547.296	597.389	1
NF-NST XPNDR	26.917	46.290	57.600	1
XPONDR CABLE	8.146	14.089	17.459	1
MD GN ANT.AB	1.779	0.709	1.779	3
ANT MAST.SH	210.856	4.252	204.658	11
SW-FLT NTWRK	10.443	6.375	13.663	1
PREMOD PROC	28.548	13.255	23.591	1
CIP	33.791	133.354	189.794	1
CDU	112.595	145.872	117.625	1
PTP	113.456	87.535	92.575	1
TP RCRDR1	165.756	290.417	354.167	1
TP RCRDR2	165.750	290.417	354.167	1
S/C HARNESS	21127.492	21127.492	20218.742	4
SENSOR	9.660	9.663	9.660	1
ELECTRONICS	62.361	76.185	71.052	1
THRML BLNKT	0.0	0.0	0.0	1
PREAMPS	4.369	0.218	3.444	1
PREAMPS	6.559	0.218	0.444	1
PREAMPS	0.218	6.563	0.444	1
PREAMPS	6.218	0.363	0.444	1
ELECTRONICS	356.278	356.278	512.400	1
SHORT EL ANT	3.933	7.201	7.201	10
SH EL ANT EL	0.846	0.852	1.176	1
SEARCH COIL	6.421	6.421	9.042	12
SRCH COIL EL	0.254	0.254	0.090	1
LOOP ANTENNA	146.847	146.847	6.670	4
LOOP ANTENNA	146.847	146.847	6.670	4
LOOP ANTENNA	0.054	69.444	69.444	2
LOOP ANTENNA	0.354	69.444	69.444	2
VIS SENSOR	460.980	627.190	555.480	13
VIS SENSOR	460.980	627.190	555.480	13
VUV SENSOR	460.386	627.190	555.480	13
VIS COVER	4.284	8.492	4.284	11
VIS COVER	4.284	8.492	4.284	11
VUV COVER	[illegible]	4.284	4.284	10
DCU	4.499	6.379	2.652	1
ELECTRONICS	69.975	52.455	76.575	1
FET ASSY	51.297	36.969	51.297	3
HVPS	11.542	8.742	12.762	1
PPS	23.165	17.445	25.525	1
RAD SHLD	7.326	5.261	7.326	3
CABLING	3.461	2.914	4.254	1
ELECTRONICS	43.813	27.365	43.813	1
SENSOR	54.925	34.456	55.581	1
SENSOR	54.925	34.456	55.581	1
SENSOR	54.766	32.852	53.164	1
EIC	228.123	488.323	514.658	13
DISPENSER	193.600	167.390	47.900	13
DISPENSER	193.600	167.390	47.900	13
INBRD WIRE	1.114	1.684	1.991	1

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INNER WIRE	1.114	1.584	1.991	1
OUTER WIRE	0.340	0.525	0.622	1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TIP MASS	0.091	0.137	0.162	1
TIP MASS	0.091	0.137	0.162	1
DISPENSER	[illegible]	[illegible]	[illegible]	[illegible]
DISPENSER	56.757	55.536	65.668	1
PWI SUBASSY	10.912	0.225	10.912	11
PWI WIRE	[illegible]	[illegible]	[illegible]	[illegible]
S/C BALANCE	112.935	112.935	112.935	1
RAD BAL	[illegible]	77.456	38.827	3
BAST	[illegible]	[illegible]	[illegible]	[illegible]
ASTRO MOUR	146.000	292.000	292.000	2
BAST	58.100	29.050	58.000	5
ASTRO MOUR	[illegible]	[illegible]	[illegible]	[illegible]
HARNESS.PWI	81.250	162.500	162.500	2
HARNESS.BAG	40.000	20.000	40.000	2

DYNAMICS EXPLORER DE-A
MOMENT OF INERTIA CALCULATIONS
BOX AXIS ROTATION FOR NONPARALLEL AXES

NAME	IXX	IYY	IZZ	IXY	IXZ	IYZ	AN61	AN62	AN63	AN64
UPPER RP	4185.879	4185.879	8241.000							
LOWER RP	4185.879	4185.879	8241.000							
CENTER CYL	4[illegible]	4[illegible]	354.320							
SMR PANEL 1	3[illegible]	121.746	64.330	0.000	-0.000	0.000	180.0	270.0	90.0	90.0
SMR PANEL 2	5[illegible]	13[illegible]	72.116							
SMR PANEL 3	111.000	74.748	72.116	31.225	0.000	-0.000	60.0	150.0	90.0	90.0
SMR PANEL 4	56.[illegible]	121.554	64.619	-0.[illegible]	0.000	-0.000	0.0	90.0	90.0	90.0
SMR PANEL 5	4[illegible]	13[illegible]	64.887	-31.226	0.000	-0.000	300.0	60.0	90.0	90.0
SMR PANEL 6	111.[illegible]	74.748	72.116	31.225	-0.000	0.000	240.0	330.0	90.0	90.0
SEP ADPT UPR	1249.[illegible]	1[illegible]	5[illegible]							
SEP ADPT LWR	1[illegible]	1[illegible]	589.[illegible]							
SILLS MU	6 38.762	6 38.762	11934.547							
END MU	834.[illegible]	834.088	1669.181							
SIDES MU	6138.762	6138.762	11934.547							
END HL	834.[illegible]	834.[illegible]	1669.181							
CENTER SEC	5[illegible]	5[illegible]	11214.615							
SKIS+BISC	814.[illegible]	815.598	787.513							
COVERS+SEALS	1376.574	1376.574	1323.821							
LIFTING HDWR	229.429	229.429	220.583							
MISC EQUIP	635.[illegible]	635.[illegible]	635.616							
MINOR MECH	1.[illegible]	1.281	1.281							
LAUNCH SUPPT	0.[illegible]	0.[illegible]	1.000							
RELEASE MECH	0.[illegible]	0.[illegible]	0.[illegible]							
ATC BRACKETS	0.[illegible]	0.[illegible]	0.377							
ATC BRACKETS	0.282	0.282	0.377							
ATC BRACKETS	0.282	0.282	0.377							
ATC BRACKETS	0.282	0.282	0.377							
ATC BRACKETS	0.282	0.282	0.377							
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ATC BRACKETS	0.282	0.282	0.377							
ATC BRACKETS	0.282	0.282	0.377							
ATC BRACKETS	0.282	0.282	0.377							
ATC BRACKETS	0.282	0.282	0.377							
THR-UPR MAT	1382.532	1382.532	2332.961							
ATC-UPR MAT	4.389	4.389	8.752							
ATC-UPR MAT	4.389	4.389	8.752							
ATC-UPR MAT	4.389	4.389	8.752							
ATC-UPR MAT	4.389	4.389	8.752							
ATC-UPR MAT	4.389	4.389	8.752							
THR-L.R MAT	1382.532	1382.532	2332.961							
ATC-LWR MAT	4.389	4.389	8.752							
ATC-LWR MAT	4.389	4.389	8.752							
ATC-LWR MAT	4.389	4.389	8.752							
ATC-LWR MAT	4.389	4.389	8.752							
ATC-LWR MAT	4.389	4.389	8.752							
TEMP SENS-UR	0.0	0.0	0.0							
TEMP SENS-LR	0.0	0.0	0.0							
TH HEATERS	0.0	0.0	0.0							
BOT HOR SENS	11.873	9.152	12.625	-0.883	-0.000	0.000	30.0	150.0	90.0	90.0

DETECTOR	6.403	6.403	0.403							
DETECTOR	6.463	9.493	6.403							
NUT DAMPER	4512.600	5872.693	4512.500							
ATT COIL	1954.750	1954.750	5961.500							
MOMENT COIL	12726.500	7475.000	7470.000							
PITCH DAMPER	[illegible]	[illegible]	[illegible]							
UPPER SOL AR	10116.602	10116.602	15901.301							
LOWER SOL AR	10116.602	10116.602	15901.301							
BATT 1	272.570	96.366	385.600							
BATT 2	96.366	272.570	265.605							
PWR SUPL EL	[illegible]	507.296	507.399							
MEAST ASSM	[illegible]	46.200	57.605							
XPOWDR CABLE	0.105	14.709	17.459							
MC AN ANTOSR	1.7	3.703	1.779							
ANT MAST	[illegible]	[illegible]	300.050							
SHOFLT MTURV	[illegible]	6.575	13.663							
PREMOD PROC	[illegible]	13.256	23.591							
CIR	[illegible]	171.654	141.704							
CDU	112.595	145.472	119.625							
STM	113.456	87.335	92.575							
TL RCRDR1	[illegible]	[illegible]	300.167							
TP RCRDR2	165.759	299.417	354.167							
S/C HARNESS	21727.4	21127.492	20219.742							
SENSOR	[illegible]	[illegible]	7.531	-0.535	0.000	-0.000	14.0	356.0	90.0	90.0
ELECTRONICS	62.561	76.186	852							
THRML BLNKT	3.0	6.3	6.8							
PREAMPS	0.002	0.396	1.000	-0.145	-0.000	0.000	20.0	160.0	90.0	90.0
PREAMPS	0.042	9.296	6.444	-9.145	-0.000	0.000	20.0	116.0	90.0	90.0
PREAMPS	6.218	0.569	6.444							
PREAMPS	0.218	0.569	0.444							
ELECTRONICS	356.978	356.278	512.499							
SHORT EL ANT	5.014	1.296	7.281	2.757	0.000	0.000	65.0	155.0	90.0	90.0
SH EL ANT EL	[illegible]	[illegible]	1.136	-0.167	-0.000	0.000	65.0	155.0	90.0	90.0
SEARCH COIL	6.421	6.421	6.842							
SRCH COIL EL	3.254	0.254	0.890	-0.060	0.000	-0.000	65.0	155.0	90.0	90.0
LOOP ANTENNA	146.447	146.447	1.670							
LOOP ANTENNA	146.547	146.547	6.670							
LOOP ANTENNA	4.703	64.796	69.444	17.347	0.000	6.000	15.0	105.0	90.0	90.0
LOOP ANTENNA	0.703	60.796	69.444	-17.347	0.000	0.000	15.0	105.0	90.0	90.0
VIS SENSOR	550.463	529.417	555.479	61.798	-0.000	-0.000	230.0	320.0	90.0	90.0
VIS SENSOR	450.946	627.100	555.480							
NUN SENSOR	627.467	400.413	556.486	-53.302	0.000	0.000	140.0	200.0	90.0	90.0
VIS COVER	4.238	4.776	4.284	-1.353	0.000	0.000	110.0	200.0	90.0	90.0
VIS COVER	0.753	6.123	4.284	2.072	-0.000	0.000	239.0	320.0	90.0	90.0
NUN COVER	[illegible]	[illegible]	4.284							
UCU	4.649	6.379	2.652							
ELECTRONICS	79.495	52.455	75.575							
DET ASSY	47.718	40.551	41.307	-6.320	-0.000	0.000	30.0	180.0	90.0	90.0
MVPS	11.552	8.742	12.762							
PFS	23.165	17.485	25.625							
RAD SHLD	6.416	4.706	7.130	-0.006	-0.000	0.000	30.0	180.0	90.0	90.0
CABLING	3.851	2.314	4.254							
ELECTRONICS	43.613	27.363	43.613							
SENSOR	50.025	30.456	55.581							
SENSOR	54.925	34.456	55.581							
SENSOR	49.936	37.381	53.164	-9.084	-0.000	0.000	20.0	110.0	90.0	90.0
EIC	[illegible]	[illegible]	[illegible]							
DISPENSER	193.800	167.300	47.900							
DISPENSER	193.800	167.300	47.900							
IMPRO WIRE	1.463	1.131	1.000	0.002	-0.000	0.050	20.0	170.0	90.0	90.0

INBOARD WIRE	1.567	1.131	1.991	0.097	-0.000	0.000	80.0	170.0	90.0	90.0
OUTBRD WIRE	0.521	0.333	0.622	0.050	-0.000	0.000	80.0	170.0	90.0	90.0
OUTBRD WIRE	0.521	[illegible]	0.622	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TIP MASS	0.135	0.292	0.162	0.068	-0.000	0.000	80.0	170.0	90.0	90.0
TIP MASS	0.135	0.292	0.162	0.008	-0.000	0.000	80.0	170.0	90.0	90.0
DISPENSER	[illegible]	[illegible]	[illegible]	3.215	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DISPENSER	54.[illegible]9	37.334	6[illegible].660	3.215	-0.306	0.000	80.0	170.0	90.0	90.0
PWR SUPPLY	2.134	9.764	10.912	-4.094	-0.000	0.000	65.0	195.0	90.0	90.0
PWR MISC	2.721	1.538	2.650	-0.737	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S/C BALANCE	112.933	112.933	112.933							
MAG BAL	75.1[illegible]	41.10[illegible]	30.887	9.053	0.000	-0.360	76.0	166.0	90.0	90.0
MAST	[illegible]	[illegible]	[illegible]	-11.100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ASTRO MO.R	172.074	263.923	292.000	-59.921	-0.000	0.000	150.0	245.0	90.0	90.0
MAST	34.16[illegible]	52.220	54.000	-11.100	-0.000	0.000	65.0	195.0	90.0	90.0
ASTRO MO.R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HARNESS.PWR	35.7[illegible]2	147.988	162.500	-31.121	-0.000	0.000	150.0	245.0	90.0	90.0
HARNESS.MAS	23.572	36.426	49.000	-7.663	-0.000	0.000	65.0	195.0	90.0	90.0

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DYNAMICS EXPLORER DE-A
MOMENT OF INERTIA CALCULATIONS ABOUT S/CAXIS

AN ASTERISK INDICATES THE TOTAL SUM OF THE MOMENTS OF BOX COMPONENTS

ID	NAME	IXX	IYY	IZZ
1011100	UPPER HP	5828.5781	5828.5781	8291.8980
1010200	LOWER EP	5785.6336	5785.6336	8281.4380
1010301	CENTER COL	480.3461	480.3481	350.3281
[illegible]	SHR PANL NO 1	56.9212	683.5625	623.4479
[illegible]	SHR PANL 2	581.2376	277.7984	[illegible]
1011304	SHR PANL 3	555.3218	223.3158	664.8818
[illegible]	SHR PANL 4	56.9212	480.6509	623.7354
1010366	SHR PANL 5	[illegible]	347.6315	606.7728
[illegible]	SHR PANL 6	555.3218	223.3158	664.8818
[illegible]	SEP SUPT UPR	5475.6466	5475.6406	553.3866
[illegible]	SEP SUPT LWR	5832.8842	5832.8842	588.3888
[illegible]	STIFFS HU	8491.8828	8491.8828	10534.5469
[illegible]	[illegible] HU	3836.6760	3836.6760	1463.1614
1012701	STIFFS HL	8491.8828	8491.8828	10534.5469
1011702	[illegible] HL	3836.8760	3836.8765	1669.1814
[illegible]	CENTER RING	5619.4062	5619.4062	11214.9164
[illegible]	[illegible] MISC	813.3896	816.3897	387.6123
1011204	CONVERSO STALS	1376.5745	1376.5745	1323.0215
1011306	LIFTING HDWR	229.4291	229.4291	228.5634
[illegible]	N [illegible] BOX	665.5117	665.5147	438.8183
[illegible]	FIRE MECH	1521.1625	944.7812	877.2812
[illegible]	LAUNCH SUPPT	794.1250	944.1250	151.8008
[illegible]	RELEASE HDWR	1458.8146	[illegible]	[illegible]
1011700	ATC BRACKETS	144.3358	228.1905	184.4990
[illegible]	ATC BRACKETS	271.0171	135.1356	101.2956
[illegible]	ATC BRACKETS	176.7371	193.4682	180.1380
[illegible]	ATC BRACKETS	148.3558	219.5621	188.2986
[illegible]	ATC BRACKETS	236.7958	137.2171	105.9856
[illegible]	ATC BRACKETS	176.5858	180.6171	101.2856
[illegible]	ATC BRACKETS	144.3358	228.1905	184.4996
[illegible]	ATC BRACKETS	231.0171	138.3658	101.2956
1011800	ATC BRACKETS	176.7371	193.4680	180.1380
1011890	ATC BRACKETS	148.3858	219.5621	180.2906
[illegible]	ATC BRACKETS	236.7958	137.2171	105.9856
[illegible]	ATC BRACKETS	178.5858	180.6171	101.2856
1020101	THRUSTER HAT	1712.0417	1712.6417	2332.0605
[illegible]	ATC-UPR HAT	147.6627	231.0167	112.2522
[illegible]	ATC-UPR HAT	233.8268	141.6087	109.8679
1020102	ATC-UPR HAT	177.8824	196.4937	107.9490
[illegible]	ATC-UPR HAT	151.6567	222.8374	108.8689
1020142	ATC-UPR HAT	239.5767	140.5864	113.7299
[illegible]	ATC-UPR HAT	181.6287	193.6664	109.0679
[illegible]	THR-LWR HAT	1712.0417	1712.6417	2332.0605
[illegible]	ATC-LWR HAT	147.6627	231.0167	112.2522
[illegible]	ATC-LWR HAT	233.8268	141.6087	109.8679
[illegible]	ATC-LWR HAT	177.8824	196.4937	107.9490
[illegible]	ATC-LWR HAT	181.6587	222.8374	108.8689
[illegible]	ATC-LWR HAT	239.5797	140.5864	113.7299
1020202	ATC-L-R HAT	181.6287	193.0664	109.0679
1020301	TEMP SENS-UR	18.3750	18.3750	0.0
1020401	TEMP SENS-LR	18.3750	18.3750	0.0
1020500	TH HEATERS	0.0	0.0	0.0
1030100	[illegible] HOR SENS	1463.8891	987.1370	1568.0846

103?302	DETECTOR	276.5283	564.5283	288.4033
1030302	DETECTOR	276.5283	564.5283	288.4033
1030431	NUT DAMPER	3082.0000	8426.4992	9060.5000
1030402	ATT COIL	2256.2500	2288.2500	3901.5000
103?5??	MOMENT COIL	12726.5000	12709.0000	12709.0000
1030650	PITCH DAMPER	4680.4492	8686.4492	8458.7305
1040300	UPPER SOL AR	18522.3086	18522.3086	15901.3008
1040300	LOWER SOL AR	18522.3086	18522.3086	15901.3008
1040311	BATT 1	4190.9863	9592.5439	8304.6172
1040392	BATT 2	12042.3769	2992.7671	9605.5312
1040420	PWR SUPL EL	13361.5273	4465.4835	9737.2187
1050200	M-MST ARMOR	1480.4165	1842.4141	1231.5142
1050300	TRANSPDR CABLE	448.0208	587.5357	524.0107
1050400	[illegible] ANT.SB	2136.7783	1015.6995	1401.7786
1050500	ANT MAST.SB	746.4583	629.2506	317.4583
105?0??	S/*FLT NTWRK	845.6052	242.6895	687.1194
105?0??	PREMOD PROC	776.5476	1262.6555	675.8511
1060100	CTR	2953.9631	1599.3816	1636.3604
106?20?	CDU	3694.7146	2830.6865	2651.0847
1060300	RTM	3259.7786	1567.2996	1813.5667
1060411	TM ACQDR1	3469.0625	6513.4445	6186.5820
1060402	TM ACQDR2	2758.5623	6565.1523	4567.6133
108?0??	S/C HARNESS	21027.4922	21027.4922	20218.7422
109?101	S USO	1517.4618	122.5459	1563.4328
109?102	ELECTRONICS	2105.0051	1436.5259	1482.2339
1090105	THRML BLNKT	0.0	0.0	0.0
1090201	PREAMPS	101.5542	1.3648	102.5753
1090201	PREAMPS	101.5542	1.3648	132.5753
1091201	PREAMPS	57.5393	55.4843	2.8493
1094201	PREAMPS	57.5353	55.4443	2.0493
1090202	ELECTRONICS	8432.1250	3692.2161	5252.3125
1090204	SHORT EL ANT	35.3155	154.6882	190.2012
1090205	SH EL ANT EL	71.5296	354.4502	426.3760
1090206	SEARCH COIL	93.1211	333.1208	413.4419
1090207	SRCH COIL EL	92.7341	348.7339	441.0500
1090208	LOOP ANTENNA	498.8872	1152.1671	1453.7896
1090208	LOOP ANTENNA	828.9270	146.8473	682.1494
1090209	LOOP ANTENNA	740.6323	695.5654	657.6438
1091209	LOOP ANTENNA	740.6323	605.5654	657.6438
1090301	VIS SENSOR	2565.9834	2817.7031	4846.4683
1090301	VIS SENSOR	913.2012	4302.2578	4678.2656
1090302	XUV SENSOR	4702.2574	697.2126	4462.2734
1090303	VIS COVER	580.0942	66.8811	631.2516
1090303	VIS COVER	357.6118	269.7344	612.6221
1091304	XUV COVER	31.8062	576.3782	583.2620
1090396	DCU	201.7275	200.3654	259.7097
1090401	ELECTRONICS	5178.1841	2453.7432	3206.0547
1090402	DET ASSY	1055.8718	3052.1157	3874.1340
1090403	HVPS	529.6970	408.5570	534.3423
1090404	[illegible]S	1059.3945	817.1143	1068.6844
1090405	RAD SHLD	150.8349	836.4151	553.4475
1090405	CABLING	176.5658	136.3191	178.1142
1090501	ELECTRONICS	906.9724	3624.5800	2805.0708
1090502	SENSOR	2626.0186	6231.3281	3689.7998
1090502	SENSOR	2626.0186	6231.3281	3689.7998
1090502	SENSOR	1775.3291	3934.4751	3941.9138
1090606	EIC	3807.6101	7402.1797	5582.7305
1090702	DISPENSER	594.0044	567.5044	47.9000
1090702	DISPENSER	594.0044	567.5044	47.9000
1090801	THRD WIRE	65.6667	6.6911	71.7511

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1990801	INBRD WIRE	65.6667	6.8911	71.7511
1090802	OUTBRD WIRE	20.5208	2.1535	22.4222
1090802	OUTBRD WIRE	20.5208	2.1535	22.4222
1090803	TIP MASS	5.3354	0.5599	5.8298
1090803	TIP MASS	5.3354	0.5599	5.8298
1090804	DISPENSER	2145.7600	227.2756	2366.4397
1090804	DISPENSER	2145.7640	227.2756	2366.4397
1090901	[illegible] SUBASSY	178.5338	873.[illegible]133	1352.2122
1090902	PWL HINGE	250.2728	1589.[illegible]	1638.[illegible]
1101100	S/C BALANCE	112.9333	112.[illegible]333	112.9333
1101200	[illegible]AL	1140.3845	4784.[illegible]14F	5647.1045
1301101	MAST	205.7667	771.[illegible]	648.2297
1301102	ASTRO MOWR	1035.9290	3883.9199	4773.8437
1302201	MAST	205.7667	771.4634	648.2297
1302202	ASTRO MOWR	1035.9290	3883.9199	4773.8437
1303300	HARNESS.PWI	576.5015	2161.4280	2656.6794
1304400	HARNESS.MAG	141.9061	532.1437	653.9517

DYNAMICS EXPLORER DE-A
S/C MOMENTS OF INERTIA
01 OCTOBER 1978 Stowed Before balancing.

THE TOTALS BEFORE BALANCING ARE-

```
SUM OF WEIGHTS= 0.78[illegible]215E+03
SUM OF WEIGHT * X DISTANCE=-0.34[illegible]4735[illegible]E+03
SUM OF WEIGHT * Y DISTANCE= 0.91[illegible]241[illegible]E+02
SUM OF WEIGHT * Z DISTANCE=-0.[illegible]E+03
SUM OF WEIGHT * Y * Z DISTANCES=-0.2[illegible]4232501E+04
SUM OF WEIGHT * Y * Z DISTANCES=-0.[illegible]6349241E+04
SUM OF WEIGHT * X * Y DISTANCES=-0.1[illegible]810[illegible]27E+04
SUM OF WEIGHT * X2= 0.[illegible]241250E+05
SUM OF WEIGHT * Y2= 0.55562875E+05
SUM OF WEIGHT * Z2= 0.89597375E+05

SUM OF IXX= 0.1[illegible]E+[illegible]
SUM OF IYY= 0.10456737E+06
SUM OF IZZ= 0.14[illegible]111[illegible]4E+06
```

THE C.G. COMPONENTS ARE-- X= -0.446[illegible]14E+00 Y= 0.117274E+00 Z= -0.706135E+[illegible]

```
SUM OF IXY=-0.8[illegible]0609[illegible]5E+02
SUM OF IXZ= 0.0
SUM OF IYZ= 0.0
```

DYNAMICS EXPLORER DE-A
S/C MOMENTS OF INERTIA
01 OCTOBER 1978

S/C MOMENTS OF INERTIA ARE-

* THE FOLLOWING VALUES HAVE UNITS OF LB.-IN2
IX= 0.26[illegible]E+06
IY= 0.274844[illegible]E+06
IZ= 0.294752317E+06
IXZ=-0.[illegible]E+04
IYZ=-0.277[illegible]E+04
IYY=-0.172[illegible]E+04
IMAX= 0.275[illegible]E+06
IMIN= 0.26[illegible]E+06

* THE FOLLOWING VALUES HAVE UNITS OF LB-FT-SEC2
IYX= 0.675[illegible]E+03
IYY= 0.711[illegible]E+03
IZZ= 0.763[illegible]E+03
IXZ=-0.5[illegible]E+01
IYZ=-0.717[illegible]E+01
IYX=-0.[illegible]E+01
IMAX= 0.712[illegible]E+03
IMIN= 0.674[illegible]E+03

INERTIA RATIO

$I_{SPIN}/I_{TRANSVERSE\ MAX}$ = 1.072

DYNAMICS EXPLORER DE-A
S/C MOMENTS OF INERTIA
1 OCTOBER 1978

THE TOTALS B FORE BALANCING ARE-

SUM OF WEIGHTS= 0.7[illegible]3115E+03
SUM OF WEIGHT * X DISTANCE=-0.34[illegible]539E+03
SUM OF WEIGHT * Y DISTANCE= 0.9152A1[illegible]E+02
SUM OF WEIGHT * Z DISTANCE=-0.3518[illegible]E+03
SUM OF WEIGHT * X * Z DISTANCES=-0.2[illegible]3250E+04
SUM OF WEIGHT * Y * Z DISTANCES=-0.2[illegible]92A1E+00
SUM OF WEIGHT * X * Y DISTANCES=-0.16810027E+04
SUM OF WEIGHT * X2= 3.61224125E+05
SUM OF WEIGHT * Y2= 3.[illegible]5582875E+05
SUM OF WEIGHT * Z2= 3.4959737[illegible]E+05

SUM OF IXX= [illegible]
SUM OF IYY= 3.1945[illegible]737E+06
SUM OF IZZ= [illegible]

X1= -20.000 X = 20.000 Y1= -20.000 Y2= 20.000 Z1= 15.000 Z2= -15.000

BALANCE WEIGHTS AND LOCATIONS

	WEIGHT	X	Y	Z
(1)	-12.1157	-20.0000	0.0	15.0000
(2)	5.3[illegible]	20.0000	0.0	-15.0000
(3)	-2.[illegible]	0.0	-20.0000	15.0000
(4)	-7.013[illegible]	0.0	20.0000	-15.0000

THE SUM OF THE BALANCE WEIGHTS IS 26.[illegible]

THE C.G. CORRECTIONS ARE-- X= -0.380216E-06 Y= 0.756[illegible]E-07 Z= -0.441166E-00

SUM OF IXY=-0.36781933E+02
SUM OF IXZ= 0.0
SUM OF IYZ= 0.0

NOTE THAT A NEGATIVE BALANCE WEIGHT DENOTES THAT A NONZERO X OR Y COORDINATE IS OF OPPOSITE SIGN

THE TOTALS AFTER BALANCING ARE-

SUM OF WEIGHTS= 0.[illegible]
SUM OF WEIGHT * X DISTANCE=-0.2746582[illegible]
SUM OF WEIGHT * Y DISTANCE= 0.61[illegible]
SUM OF WEIGHT * Z DISTANCE=-0.51761621E+03
SUM OF WEIGHT * X * Z DISTANCES=-0.48828125E-03
SUM OF WEIGHT * Y * Z DISTANCES=-0.14648437E-02
SUM OF WEIGHT * X * Y DISTANCES=-0.16810027E+04
SUM OF WEIGHT * X2= 3.88193500E+05
SUM OF WEIGHT * Y2= 3.693[illegible]2750E+05
SUM OF WEIGHT * Z2= 3.95643750E+05

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DYNAMICS EXPLORER DE-A
S/C MOMENTS OF INERTIA
01 OCTOBER 1978

S/C MOMENTS OF INERTIA ARE-

* THE FOLLOWING VALUES HAVE UNITS OF LB.-IN2

IX= [illegible]
IY= [illegible]
IZ= [illegible]
IXZ=-[illegible]
IYZ=-0.1025[illegible]
IYX=-0.17[illegible]
IZX= [illegible]
IMP= [illegible]

* THE FOLLOWING VALUES HAVE UNITS OF IN-LBS-SEC2

I A= [illegible]
IYY= [illegible]
I[illegible]
I[illegible]=-0.1[illegible]
IYZ=-[illegible]
I[illegible]
IMZ= [illegible]
IRI= [illegible]

INERTIA RATIO

I /I = 1.060
SPIN/ TRANSVERSE MAX

APPENDIX B

DE-A DEPLOYED MASS PROPERTIES

COMPUTER OUTPUT

DYNAMICS EXPLORER DE-A
SPACECRAFT CONFIGURATION REPORT SYSTEM
01 OCTOBER 1978 DEPLOYED

ID	DATE	NAME	DRWG.NO.	SOURCE	ZONE	PROPOSAL WEIGHT	TARGET WEIGHT	EST/ACT WEIGHT	%TOL	WT TOL	QTY
1000000	11 1 7	DE-A	3294600-501		1.	0.0	0.0	0.0	0.0	0.0	1.
1010000	5 1 B	STRUCTURE-AE			1.	134.90	140.20	0.0	0.0	0.0	1.
1010100	11 1 7	UPPER F		AE-C	1.	0.0	0.0	23.400	0.0	0.0	1.
1010200	11 1 7	LOWER F			1.	0.0	0.0	22.600	0.0	0.0	1.
1010201	11 1 7	CEN COLISH R			1.	0.0	0.0	0.0	0.0	0.0	1.
1010301	11 1 7	CENTER COL			1.	0.0	0.0	9.200	0.0	0.0	1.
1010302	11 1 7	SHR PANEL 1			1.	0.0	0.0	2.420	0.0	0.0	1.
1010303	11 1 7	SHR PANEL 2			1.	0.0	0.0	2.420	0.0	0.0	1.
1010304	11 1 7	SHR PANEL 3			1.	0.0	0.0	2.420	0.0	0.0	1.
1010305	11 1 7	SHR PANEL 4			1.	0.0	0.0	2.420	0.0	0.0	1.
1010306	11 1 7	SHR PANEL 5			1.	0.0	0.0	2.420	0.0	0.0	1.
1010307	11 1 7	SHR PANEL 6			1.	0.0	0.0	2.420	0.0	0.0	1.
1010400	11 1 7	SEP SUPT UPR			1.	0.0	0.0	15.300	0.0	0.0	1.
1010510	3 1 B	SEP ATPI LWR			1.	0.0	0.0	16.300	0.0	0.0	1.
1010600	8 1 8	HAT UPPER			1.	0.0	0.0	0.0	0.0	0.0	1.
1010601	8 1 8	CIRCLS MU			1.	0.0	0.0	15.700	0.0	0.0	1.
1010602	10 1 8	ENG MU			1.	0.0	0.0	0.350	0.0	0.0	1.
1010700	8 1 8	HAT LOWER			1.	0.0	0.0	0.0	0.0	0.0	1.
1010701	8 1 8	SINES ML			1.	0.0	0.0	15.700	0.0	0.0	1.
1010702	10 1 8	ENG ML			1.	0.0	0.0	0.350	0.0	0.0	1.
1010800	3 1 8	CENTER RING			1.	0.0	0.0	0.0	0.0	0.0	1.
1010801	3 1 8	RING			1.	0.0	0.0	6.500	0.0	0.0	1.
1010802	3 1 8	BRACKETS			1.	0.0	0.0	0.586	0.0	0.0	1.
1011000	11 1 7	HARDWARE			1.	0.0	0.0	1.000	0.0	0.0	1.
1011100	11 1 7	BOOMS-MISC			1.	0.0	0.0	2.500	0.0	0.0	1.
1011200	11 1 7	BOOMS-SCALE			1.	0.0	0.0	0.200	0.0	0.0	1.
1011300	11 1 7	LIFTING MDUR			1.	0.0	0.0	0.700	0.0	0.0	1.
1011400	9 1 8	RF SCRNS			1.	0.0	0.0	0.0	0.0	0.0	1.
1011401	9 1 8	RF SCRNS UPR			1.	0.0	0.0	0.170	0.0	0.0	6.
1011402	9 1 8	RF SCRNS LWR			1.	0.0	0.0	0.178	0.0	0.0	6.
1011500	11 1 7	HI GREE-HDS			1.	0.0	0.0	2.000	0.0	0.0	1.
1011600	1 1 8	ANTENNA SUPT			1.	0.0	0.0	0.0	0.0	0.0	1.
1011601	1 1 8	MINOR MACH			1.	0.0	0.0	1.500	0.0	0.0	1.
1011602	1 1 8	LAUNCH SUPPT			1.	0.0	0.0	1.500	0.0	0.0	1.
1011603	1 1 8	RELEASE MDUR			1.	0.0	0.0	1.000	0.0	0.0	1.
1011700	8 1 8	ATC BRACKETS			1.	0.0	0.0	0.335	0.0	0.0	6.
1011800	9 1 8	ATC BRACKETS			1.	0.0	0.0	0.335	0.0	0.0	6.
1020000	5 1 8	THERMAL AE			1.	12.00	10.10	0.0	0.0	0.0	1.
1020100	11 1 7	THR-UPR HAT			1.	0.0	0.0	0.0	0.0	0.0	1.
1020101	8 1 8	THR-UPR HAT			1.	0.0	0.0	3.750	0.0	0.0	1.
1020102	8 1 8	ATC-UPR HAT			1.	0.0	0.0	0.335	0.0	0.0	6.
1020200	11 1 7	THR-LWR HAT			1.	0.0	0.0	0.0	0.0	0.0	1.
1020201	11 1 7	THR-LWR HAT			1.	0.0	0.0	3.750	0.0	0.0	1.
1020202	8 1 8	ATC-LWR HAT			1.	0.0	0.0	0.335	0.0	0.0	6.
1020300	11 1 7	THR-UPR B/P			1.	0.0	0.0	0.0	0.0	0.0	1.
1020301	8 1 8	TEMP SENS-UB			1.	0.0	0.0	0.240	0.0	0.0	1.
1020400	11 1 7	THR-LWR B/P			1.	0.0	0.0	0.0	0.0	0.0	1.
1020401	8 1 8	TEMP SENS-LB			1.	0.0	0.0	0.240	0.0	0.0	1.
1020500	11 1 7	TH HEATERS			1.	0.0	0.0	0.180	0.0	0.0	1.
1030000	11 1 7	ATT CONTR A			1.	62.80	62.80	0.0	0.0	0.0	1.

1298129	11	1	7	BOT HOR SENS				1.	0.0	0.0	3.000	0.0	0.0	1.
1298500	E	1	A	SUN SENSOR				1.	0.0	0.0	0.0	0.0	0.0	1.
1298501	A	1	A	ELECTRONICS				1.	0.0	0.0	1.300	0.0	0.0	1.
1298502	A	1	A	DETECTOR				1.	0.0	0.0	0.500	0.0	0.0	2.
1298400	11	1	7	NUT DRIVE COIL				1.	0.0	0.0	0.0	0.0	0.0	1.
1298401	A	1	A	NUT DAMPER				1.	0.0	0.0	13.300	0.0	0.0	1.
1298402	A	1	A	ATT COIL				1.	0.0	0.0	6.000	0.0	0.0	2.
1298500	A	1	A	MOMENT COIL				1.	0.0	0.0	31.000	0.0	0.0	1.
1298600	A	1	A	PITCH DAMPER				1.	0.0	0.0	13.000	0.0	0.0	1.
1298300	5	1	A	POWER				1.	120.10	127.10	0.0	0.0	0.0	1.
1298109	11	1	7	UPPER SOL AR	2294644-501			1.	0.0	0.0	0.0	0.0	0.0	1.
1298101	10	1	A	CELL MODULES				1.	0.0	0.0	24.600	0.0	0.0	1.
1298102	10	1	A	SHUNT WIRING				1.	0.0	0.0	3.100	0.0	0.0	1.
1298103	10	1	A	DIODES				1.	0.0	0.0	1.000	0.0	0.0	1.
1298220	11	1	7	LOWER SOL AR	2294744-501			1.	0.0	0.0	0.0	0.0	0.0	1.
1298201	10	1	A	CELL MODULES				1.	0.0	0.0	24.600	0.0	0.0	1.
1298202	10	1	A	SHUNT WIRING				1.	0.0	0.0	3.100	0.0	0.0	1.
1298203	10	1	A	DIODES				1.	0.0	0.0	1.000	0.0	0.0	1.
1298300	11	1	7	BATTERIES				1.	0.0	0.0	0.0	0.0	0.0	1.
1298301	5	1	A	BATT	2294642-501			1.	0.0	0.0	21.700	0.0	0.0	1.
1298302	5	1	A	BATT	2294643-501			1.	0.0	0.0	21.700	0.0	0.0	1.
1298400	11	1	7	PWR SUPL EL	2294645-501			1.	0.0	0.0	22.600	0.0	0.0	1.
1298003	5	1	A	CONVCTNS A				1.	16.70	18.50	0.0	0.0	0.0	1.
1298200	5	1	A	XC-HSI ANTOR	2295168-1			1.	0.0	0.0	7.600	0.0	0.0	1.
1298300	11	1	7	EXPNDR CABLE				1.	0.0	0.0	2.300	0.0	0.0	1.
1298409	10	1	A	MT SM ANT-SB				1.	0.0	0.0	1.400	0.0	0.0	1.
1298500	10	1	A	ANT MAST-SB				1.	0.0	0.0	1.000	0.0	0.0	1.
1298800	11	1	7	SW-FLT NTWRK				1.	0.0	0.0	1.800	0.0	0.0	1.
1298900	11	1	7	PR-MOD PROC				1.	0.0	0.0	4.400	0.0	0.0	1.
1298003	5	1	A	C & DH				1.	53.10	62.10	0.0	0.0	0.0	1.
1298100	11	1	7	CTP	2294670-501			1.	0.0	0.0	9.100	0.0	0.0	1.
1298200	11	1	7	CUU	2294673-501			1.	0.0	0.0	18.800	0.0	0.0	1.
1298300	11	1	7	ATP	2294671-501			1.	0.0	0.0	0.000	0.0	0.0	1.
1298006	E	1	A	TAPE P CORDR	2295174	4.16.5-2		1.	0.0	0.0	0.0	0.0	0.0	1.
1298031	E	1	A	TP RCKDRI				1.	0.0	0.0	17.000	0.0	0.0	1.
1298002	E	1	A	TP RCRDR2				1.	0.0	0.0	17.000	0.0	0.0	1.
1298006	11	1	7	S/C HARNESS	2295147-501			1.	64.70	64.70	0.0	0.0	0.0	1.
1298100	11	1	7	UPPER HARN	2294647-501			1.	0.0	0.0	27.500	0.0	0.0	1.
1298200	11	1	7	LOWER HARN	2294747-501			1.	0.0	0.0	27.500	0.0	0.0	1.
1298500	11	1	7	GROUND BLOCK				1.	0.0	0.0	0.400	0.0	0.0	1.
1298600	11	1	7	GROUND BLOCK				1.	0.0	0.0	0.300	0.0	0.0	1.
1298504	11	1	7	FITTING				1.	0.0	0.0	1.000	0.0	0.0	1.
1298600	11	1	7	CLAMPS				1.	0.0	0.0	1.000	0.0	0.0	1.
1298700	11	1	7	MST				1.	0.0	0.0	5.500	0.0	0.0	1.
1298804	11	1	7	GRND STRAP				1.	0.0	0.0	1.500	0.0	0.0	1.
1298009	5	1	A	GFE DE-A				2.	149.29	0.0	0.0	0.0	0.0	1.
1298100	5	1	A	MAG				2.	0.0	7.10	0.0	0.0	0.0	1.
1298101	9	1	A	SENSOR				2.	0.0	0.0	1.610	0.0	0.0	1.
1298102	10	1	A	ELECTRONICS				2.	0.0	0.0	7.032	0.0	0.0	1.
1298193	E	1	A	THRML BLNKT				2.	0.0	0.0	0.0	0.0	0.0	1.
1298200	5	1	A	PWI	2298126-1			2.	0.0	28.58	0.0	0.0	0.0	1.
1298201	5	1	A	PREAMPS				2.	0.0	0.0	0.330	0.0	0.0	4.
1298202	5	1	A	ELECTRONICS				2.	0.0	0.0	21.350	0.0	0.0	1.
1298234	10	1	A	SHORT EL ANT				2.	0.0	0.0	0.150	0.0	0.0	1.
1298235	10	1	A	SH EL ANT EL				2.	0.0	0.0	0.420	0.0	0.0	1.
1298266	10	1	A	SEARCH COIL				2.	0.0	0.0	0.300	0.0	0.0	1.
1298267	10	1	A	SRCH COIL EL				2.	0.0	0.0	0.320	0.0	0.0	1.
1298284	10	1	A	LOOP ANTENNA				2.	0.0	0.0	0.870	0.0	0.0	2.
1298289	10	1	A	LOOP ANTENNA				2.	0.0	0.0	0.680	0.0	0.0	2.
1298300	5	1	A	SAI				2.	0.0	38.80	0.0	0.0	0.0	1.

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1098301	10	1	B	VIS SENSOR	2295121-2		2.	0.0	0.0	11.336	0.0	0.0	2.
1098302	10	1	B	VUV SENSOR	2295121-3		2.	0.0	0.0	11.336	0.0	0.0	1.
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1098304	10	1	A	VUV COVER			2.	0.0	0.0	0.804	0.0	0.0	1.
1098305	10	1	A	DCU			2.	0.0	0.0	1.800	0.0	0.0	1.
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1098401	5	1	B	ELECTRONICS			2.	0.0	0.0	9.000	0.0	0.0	1.
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1098503	5	1	B	RIMS			2.	0.0	14.50	0.0	0.0	0.0	1.
1098501	5	1	A	ELECTRONICS	2295123-1		2.	0.0	0.0	6.000	0.0	0.0	1.
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1098700	10	1	B	TUBULAR 1.15			2.	0.0	0.20	0.0	0.0	0.0	1.
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]						2.	0.0	0.0	7.720	0.0	0.0	2.
1098802	10	1	A	PWI WIRE 350			2.	0.0	5.50	0.0	0.0	0.0	1.
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1098902	10	1	B	OUTPUT WIRE			2.	0.0	0.0	0.050	0.0	0.0	2.
1098903	10	1	B	TIP WIRE			2.	0.0	0.0	0.013	0.0	0.0	2.
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1098900	10	1	B	HOOPS			2.	0.0	0.0	0.0	0.0	0.0	1.
1098901	10	1	A	PWI SUBASSY			2.	0.0	0.0	0.900	0.0	0.0	1.
[illegible]	[illegible]						2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1100000	5	1	A	BALANCE -A-			3.	25.00	50.00	0.0	0.0	0.0	1.
1100100	10	1	A	S/C BALANCE			3.	0.0	0.0	42.350	0.0	0.0	1.
[illegible]	[illegible]						3.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1300000	5	1	A	SUPPT EQUIP			1.	0.0	45.00	0.0	0.0	0.0	1.
1300100	10	1	A	ASTRO STR.PWI			1.	0.0	0.0	0.0	0.0	0.0	1.
[illegible]	[illegible]						1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1300102	10	1	A	ASTRO HDWR			1.	0.0	0.0	11.680	0.0	0.0	1.
1300200	10	1	A	ASTROMST.MAG			1.	0.0	0.0	0.0	0.0	0.0	1.
[illegible]	[illegible]						1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1300202	10	1	A	ASTRO HDWR			1.	0.0	0.0	11.680	0.0	0.0	1.
1300300	10	1	B	HARNESS.PWI			1.	0.0	0.0	6.500	0.0	0.0	1.
[illegible]	[illegible]						1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1400000	5	1	A	EMC REVISION			1.	0.0	0.0	0.0	0.0	0.0	1.

DYNAMICS EXPLORER DE-A
WEIGHT SUMMARY BY LEVELS
21 OCTOBER 1978

ID	NAME	PROPOSAL WEIGHT		CURRENT TARGET WEIGHT	CURRENT ESTIMATED ACT WT	QTY	DRWG NO	SOURCE
[illegible]	DE-1	638.[illegible]	◆	765.00	781.8[illegible]	1.	[illegible]	
1010000	STRUCTURE-A-	134.90	◆	188.20	178.175	1.		
1010100	UPPER SP	0.0		0.0	23.400	1.		AE-C
1010200	LOWER SP	0.0		0.0	22.862	1.		
1010300	CEN COL/SM P	0.0	◆	0.0	23.727	1.		
1010301	CENTER COL	0.0		0.0	9.286	1.		
1010302	SHR PANL 1	0.0		0.0	2.427	1.		
1010303	SHR PANL 3	0.0		0.0	2.428	1.		
1010304	SHR PANL 4	0.0		0.0	2.429	1.		
1010305	SHR PANL 5	0.0		0.0	2.430	1.		
1010306	SHR PANL 6	0.0		0.0	2.428	1.		
1010307	SHR PANL 7	0.0		0.0	2.428	1.		
1010400	SCI SUPT UPR	0.0		0.0	15.300	1.		
1010500	SCI ATPT LWR	0.0		0.0	16.300	1.		
1010600	MAT UPPER	0.0	◆	0.0	20.050	1.		
1010601	SIDES MU	0.0		0.0	15.700	1.		
1010602	END MU	0.0		0.0	4.350	1.		
1010700	MAT LOWER	0.0	◆	0.0	20.050	1.		
1010701	SIDES ML	0.0		0.0	15.700	1.		
1010702	END ML	0.0		0.0	4.350	1.		
1010800	CENTER RING	0.0	◆	0.0	16.000	1.		
1010801	RING	0.0		0.0	6.500	1.		
1011002	BRACKETS	0.0		0.0	9.500	1.		
1011040	HARDWARE	0.0		0.0	1.000	1.		
1011100	SERIALIZE	0.0		0.0	2.500	1.		
1011200	COVERS+SEALS	0.0		0.0	4.200	1.		
1011300	LIFTING MDVP	0.0		0.0	0.700	1.		
1011400	RF SCRNS	0.0	◆	0.0	2.134	1.		
1011401	RF SCRNS UPR	0.0		0.0	1.068	6.		
1011402	RF SCRNS LWR	0.0		0.0	1.068	6.		
1011500	MLI BLANKS	0.0		0.0	2.000	1.		
1011600	ANTENNA SUPT	0.0	◆	0.0	4.000	1.		
1011601	HINGE MECH	0.0		0.0	1.500	1.		
1011602	LAUNCH SUPPT	0.0		0.0	1.500	1.		
1011603	RELEASE MDVR	0.0		0.0	1.000	1.		
1011700	ATC BRACKETS	0.0		0.0	2.019	6.		
1011800	ATC BRACKETS	0.0		0.0	2.019	6.		
1020000	THERMAL -A-	12.00	◆	12.10	12.075	1.		
1020100	THR-UPR MAT	0.0	◆	0.0	5.745	1.		
1020101	THR-UPR MAT	0.0		0.0	3.750	1.		
1020102	ATC-UPR MAT	0.0		0.0	1.998	6.		
1020200	THR-LWR MAT	0.0	◆	0.0	5.745	1.		
1020201	THR-LWR MAT	0.0		0.0	3.750	1.		
1020202	ATC-LWR MAT	0.0		0.0	1.998	6.		
1020300	THR-UPR B/P	0.0	◆	0.0	0.240	1.		
1020301	TEMP SENS-UB	0.0		0.0	0.240	1.		
1020400	THR-LWR B/P	0.0	◆	0.0	0.240	1.		
1020401	TEMP SENS-LB	0.0		0.0	0.240	1.		
1021500	TH HEATERS	0.0		0.0	0.100	1.		

	1350000	ATT CONTR A	62.90	•	62.90	74.380		1.									
	1350103	BDY MOM SENS	0.0		0.0	3.000		1.									
	1350300	SUN SENSOR	0.0	•	0.0	3.300		1.									
	1351361	ELECTRONICS	0.0		0.0	1.300		1.									
	1351302	DETECTOR	0.0		0.0	1.000		2.									
	1352000	NUT ELEMCOIL	0.0	•	0.0	25.000		1.									
	1353401	NUT DAMPER	0.0		0.0	15.000		1.									
	1353492	ATT COIL	0.0		0.0	12.000		2.									
	1353533	MOMENT COIL	0.0		0.0	31.000		1.									
	1353693	PITCH DAMPER	0.0		0.0	15.000		1.									
	1360000	PWR	120.10	•	127.10	123.560		1.									
	1360100	UPPER SOLAR	0.0	•	0.0	28.700		1.	2294644-501								
	1360171	CELL MODULES	0.0		0.0	24.600		1.									
	1360172	SHUNT WIRING	0.0		0.0	3.100		1.									
	1360173	DIODES	0.0		0.0	1.000		1.									
	1360200	LOWER SOLAR	0.0	•	0.0	28.700		1.	2294744-501								
	1360201	CELL MODULES	0.0		0.0	24.600		1.									
	1360202	SHUNT WIRING	0.0		0.0	3.100		1.									
	1360203	DIODES	0.0		0.0	1.000		1.									
	1360300	BATTERIES	0.0	•	0.0	43.400		1.									
	1360301	BATT 1	0.0		0.0	21.700		1.	2294643-501								
	1360302	BATT 2	0.0		0.0	21.700		1.	2294642-501								
	1360400	PWR SUPL EL	0.0		0.0	22.600		1.	2294640-501								
	1360800	CONNCTNS A	16.78	•	18.58	18.500		1.									
	1360830	ANTENNA PROB	0.0		0.0	7.600		1.	2295100-1								
	1360840	ANTENNA CABLE	0.0		0.0	2.300		1.									
	1360888	MD CH ANTENN	0.0		0.0	1.400		1.									
	1360900	ANT MAST.SR	0.0		0.0	1.000		1.									
	1360910	SW.FLT NTWRK	0.0		0.0	1.800		1.									
	1360966	REFROR PROC	0.0		0.0	0.400		1.									
	1361000	C & DH	53.10	•	62.30	62.300		1.									
	1361100	CTP	0.0		0.0	9.100		1.	2294678-501								
	1361200	CDH	0.0		0.0	10.000		1.	2294673-501								
	1361300	RTU	0.0		0.0	8.400		1.	2294671-501								
	1361400	TAPE RECORDR	0.0	•	0.0	34.300		1.	2295174	0.16.5-2							
	1361401	TP RCRDR1	0.0		0.0	17.000		1.									
	1361402	TP RCRDR2	0.0		0.0	17.000		1.									
	1362000	S/C HARNESS	64.70	•	64.70	64.700		1.	2295147-501								
	1362100	UPPER HARN	0.0		0.0	37.500		1.	2294647-501								
	1362200	LOWER HARN	0.0		0.0	27.500		1.	2294747-501								
	1362300	GROUND BLOCK	0.0		0.0	0.400		1.									
	1362400	GROUND BLOCK	0.0		0.0	0.300		1.									
	1362500	POTTING	0.0		0.0	1.000		1.									
	1362600	CLAMPS	0.0		0.0	1.800		1.									
	1362700	MAT	0.0		0.0	5.500		1.									
	1362800	GRND STRAP	0.0		0.0	1.500		1.									
	1399000	GFE DE-A	149.29	•	192.20	172.122		1.									
	1399100	RA	0.0	•	7.10	8.642		1.									
	1399101	SENSOR	0.0		0.0	1.610		1.									
	1399102	ELECTRONICS	0.0		0.0	7.032		1.									
	1399103	THERM BLNKT	0.0		0.0	0.0		1.									
	1890200	PVI	0.0	•	28.50	26.960		1.	2295125-1								
	1890201	PREAMPS	0.0		0.0	1.320		4.									
	1890202	ELECTRONICS	0.0		0.0	21.384		1.									
	1890204	SHORT EL ANT	0.0		0.0	0.150		1.									
	1890205	SM EL ANT EL	0.0		0.0	0.420		1.									
	1890206	SEARCH COIL	0.0		0.0	0.380		1.									
	1890207	SRCH COIL EL	0.0		0.0	0.327		1.									
	1890208	LOOP ANTENNA	0.0		0.0	1.749		2.									
	1890209	LOOP ANTENNA	0.0		0.0	1.360		2.									

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1090300	SAT	0.0	•	30.00	30.220	1.	
1090301	VIS SENSOR	0.0		0.0	22.672	2.	2295121-2
1090302	NUV SENSOR	0.0		0.0	11.336	1.	2295121-3
1090303	VIS COVER	0.0		0.0	1.608	2.	
1090304	VUV COVER	0.0		0.0	0.804	1.	
1090305	DCU	0.0		0.0	1.000	1.	
1091000	MAPI	0.0	•	22.00	22.000	1.	2295120-1
1091001	ELECTRONICS	0.0		0.0	0.000	1.	
1090002	DET ASSY	0.0		0.0	7.000	1.	
1090003	HVPS	0.0		0.0	1.505	1.	
1090004	PS	0.0		0.0	3.000	1.	
1090005	BAD SHLD	0.0		0.0	1.000	1.	
1090006	CABLING	0.0		0.0	0.500	1.	
1090007	MIRS	0.0	•	14.50	28.500	1.	
1090101	ELECTRONICS	0.0		0.0	6.000	1.	2295121-1
1090102	SENSOR	0.0		0.0	22.500	3.	2295123-2
1090103	EIC	0.0		18.40	18.401	1.	2295121-1
1090110	TURBAR 1-13	0.0	•	0.20	16.000	1.	
1091701	TUBE SCINTNA	0.0		0.0	0.960	2.	
1091702	DISPENSER	0.0		0.0	15.440	2.	
1090000	DET ASSY SAC	0.0	•	0.00	11.000	1.	
1090101	LARGE MIRR	0.0		0.0	0.320	2.	
1090102	OUTER MIRR	0.0		0.0	0.100	2.	
1090103	TUB GASS	0.0		0.0	0.036	2.	
1090104	DISPENSER	0.0		0.0	10.550	2.	
1090050	HOOPS	0.0	•	0.0	2.000	1.	
1090051	DET SUBASSY	0.0		0.0	0.000	1.	
1090052	DET HINGE	0.0		0.0	1.100	1.	
1090000	BALANCE -A-	25.00	•	50.00	50.000	1.	
1090100	S/C BALANCE	0.0		0.0	43.350	1.	
1090200	MAG TAL	0.0		0.0	7.650	1.	
1300000	SUPT EQUIP	0.0	•	45.00	34.100	1.	
1300100	ASTRONST.DAT	0.0	•	0.0	10.000	1.	
1301101	MAST	0.0		0.0	2.320	1.	
1301102	ASTRO MOUR	0.0		0.0	11.680	1.	
1300200	ASTRONST.MAG	0.0	•	0.0	10.000	1.	
1302201	MAST	0.0		0.0	2.320	1.	
1302202	ASTRO MOUR	0.0		0.0	11.680	1.	
1300300	HARNESS.DAT	0.0		0.0	0.000	1.	
1300400	HARNESS.MAG	0.0		0.0	1.600	1.	
1001000	EPC REVISION	0.0	•	0.0	0.0	1.	

DYNAMICS EXPLORER DE-A
ZONE AND PHASE SUMMARY
AS OCTOBER 1978

ZONE	PROPOSAL WEIGHT	CURRENT TARGET WEIGHT	CURRENT ESTIMATED WEIGHT
1	464.40	572.80	568.360
2	149.29	142.20	172.122
3	25.00	50.00	50.000

PHASE	PROPOSAL WT	CURRENT TARGET WT	CURRENT EST/ACT WT
TOTAL SYSTEM LAUNCH WEIGHT INCL PAL WT	638.69	765.00	791.831
SPACECRAFT MANAGER WEIGHT INCL PAL	464.40	572.80	568.360
GFE INSTRUMENTATION WEIGHT	149.29	142.20	172.122
TOTAL BALANCE WEIGHT	25.00	50.00	50.000

DYNAMICS EXPLORER DE-A
INPUT MOMENT OF INERTIA AND C.G. INFORMATION
01 OCTOBER 1978

NOMENCLATURE	ID.NO.	IP	MD	PA	IX/IXX	IY/IYY	IZ/IZZ	RAD.0	RAD.1	XBAR	YBAR	ZBAR	WEIGHT
UPPER BP	1010100	13	1	0	4145.9	4145.9	8291.8	0.0	0.0	0.0	0.0	-8.5	23.40
LOWER BP	1010200	13	1	0	4145.9	4145.9	8291.8	0.0	0.0	0.0	0.0	8.5	23.40
CENTER COL	1010301	13	1	0	480.3	480.3	354.3	0.0	0.0	0.0	0.0	0.0	9.29
SHR PANL 1	1010302	1	1	1	17.9	0.1	16.8	0.0	0.0	-15.2	0.0	0.0	2.42
SHR PANL 2	1010303	1	1	0	17.9	0.1	16.8	0.0	0.0	-7.6	13.6	0.0	2.42
SHR PANL 3	1010304	1	1	1	17.9	0.1	16.8	0.0	0.0	7.8	13.6	0.0	2.42
SHR PANL 4	1010305	1	1	1	17.9	0.1	16.8	0.0	0.0	15.2	0.0	0.0	2.42
SHR PANL 5	1010306	1	1	1	17.9	0.1	16.8	0.0	0.0	7.8	-13.6	0.0	2.42
SHR PANL 6	1010307	1	1	1	17.9	0.1	16.8	0.0	0.0	-7.8	-13.6	0.0	2.42
SEP ADPT UPR	1010400	13	1	0	1264.7	1264.7	553.3	0.0	0.0	0.0	0.0	-16.6	15.30
SEP ATPT LWR	1010500	13	1	0	1346.2	1346.2	588.3	0.0	0.0	0.0	0.0	16.6	16.30
SIDES HU	1010601	9	1	0	0.0	0.0	20.9	26.6	26.2	0.0	0.0	-12.5	15.70
END HU	1010602	9	1	0	0.0	0.0	0.5	26.2	0.0	0.0	0.0	-22.5	4.35
SIDES HL	1010701	9	1	0	0.0	0.0	20.9	26.6	26.2	0.0	0.0	12.5	15.70
END HL	1010702	9	1	0	0.0	0.0	0.5	26.2	0.0	0.0	0.0	22.5	4.35
CENTER MISC	1010800	9	1	0	0.0	0.0	3.0	26.5	26.4	0.0	0.0	0.0	16.00
BRKTS+MISC	1011100	4	1	0	0.0	0.0	45.2	25.1	0.0	0.0	0.0	0.0	3.50
COVERS+SEALS	1011200	4	1	0	0.0	0.0	45.2	25.1	0.0	0.0	0.0	0.0	4.20
LIFTING HOOK	1011300	4	1	0	0.0	0.0	45.2	25.1	0.0	0.0	0.0	0.0	6.70
MPAGE+HDX	1011500	4	1	0	0.0	0.0	45.2	25.1	0.0	0.0	0.0	0.0	3.80
HINGE PIN	1011601	1	1	0	2.0	2.5	2.5	0.0	0.0	-10.0	22.0	-23.0	1.50
LAUNCH SUPPT	1011602	1	1	0	2.0	2.0	1.0	0.0	0.0	-10.0	0.0	-23.0	1.50
RELEASE MECH	1011603	1	1	0	2.0	2.0	1.0	0.0	0.0	-10.0	-23.0	-23.0	1.60
ATC BRACKETS	1011700	4	1	0	0.0	0.0	0.7	1.5	0.0	-16.8	5.5	-20.0	0.33
ATC BRACKETS	1011701	4	1	0	0.0	0.0	0.7	1.5	0.0	-3.5	17.0	-20.0	0.33
ATC BRACKETS	1011702	4	1	0	0.0	0.0	0.7	1.5	0.0	13.3	11.0	-20.0	0.33
ATC BRACKETS	1011703	4	1	0	0.0	0.0	0.7	1.5	0.0	16.0	-6.5	-20.0	0.33
ATC BRACKETS	1011704	4	1	0	0.0	0.0	0.7	1.5	0.0	3.0	-17.5	-20.0	0.33
ATC BRACKETS	1011705	4	1	0	0.0	0.0	0.7	1.5	0.0	-13.0	-11.5	-20.0	0.33
ATC BRACKETS	1011800	4	1	0	0.0	0.0	0.7	1.5	0.0	-16.8	5.5	20.0	0.33
ATC BRACKETS	1011801	4	1	0	0.0	0.0	0.7	1.5	0.0	-3.5	17.0	20.0	0.33
ATC BRACKETS	1011802	4	1	0	0.0	0.0	0.7	1.5	0.0	13.3	11.0	20.0	0.33
ATC BRACKETS	1011803	4	1	0	0.0	0.0	0.7	1.5	0.0	16.0	-6.5	20.0	0.33
ATC BRACKETS	1011804	4	1	0	0.0	0.0	0.7	1.5	0.0	3.0	-17.5	20.0	0.33
ATC BRACKETS	1011805	4	1	0	0.0	0.0	0.7	1.5	0.0	-13.0	-11.5	20.0	0.33
THR-UPR HAT	1020101	9	1	0	0.0	0.0	20.9	25.0	24.9	0.0	0.0	-10.4	3.75
ATC-UPR HAT	1020102	4	1	0	0.0	0.0	0.7	7.3	0.0	-16.8	5.5	-20.0	0.33
ATC-UPR HAT	1020103	4	1	0	0.0	0.0	0.7	7.3	0.0	-3.5	17.0	-20.0	0.33
ATC-UPR HAT	1020104	4	1	0	0.0	0.0	0.7	7.3	0.0	13.3	11.0	-20.0	0.33
ATC-UPR HAT	1020105	4	1	0	0.0	0.0	0.7	7.3	0.0	16.0	-6.5	-20.0	0.33
ATC-UPR HAT	1020106	4	1	0	0.0	0.0	0.7	7.3	0.0	3.0	-17.5	-20.0	0.33
ATC-UPR HAT	1020107	4	1	0	0.0	0.0	0.7	7.3	0.0	-13.0	-11.5	-20.0	0.33
THR-LWR HAT	1020201	9	1	0	0.0	0.0	20.9	25.0	24.9	0.0	0.0	10.4	3.75
ATC-LWR HAT	1020202	4	1	0	0.0	0.0	0.7	7.3	0.0	-16.8	5.5	20.0	0.33
ATC-LWR HAT	1020203	4	1	0	0.0	0.0	0.7	7.3	0.0	-3.5	17.0	20.0	0.33
ATC-LWR HAT	1020204	4	1	0	0.0	0.0	0.7	7.3	0.0	13.3	11.0	20.0	0.33
ATC-LWR HAT	1020205	4	1	0	0.0	0.0	0.7	7.3	0.0	16.0	-6.5	20.0	0.33
ATC-LWR HAT	1020206	4	1	0	0.0	0.0	0.7	7.3	0.0	3.0	-17.5	20.0	0.33
ATC-LWR HAT	1020207	4	1	0	0.0	0.0	0.7	7.3	0.0	-13.0	-11.5	20.0	0.33
TEMP SENS-HB	1020301	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.20
TEMP SENS-LB	1020401	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.20
TH HEATERS	1020500	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10
RDY MDR SENS	1030100	1	1	1	4.5	3.5	3.9	0.0	0.0	7.9	-21.3	-5.5	1.60

ORIGINAL PAGE IS OF POOR QUALITY

DETECTOR	1030302	1	1	0	2.2	2.2	2.2	0.0	0.0	-24.0	0.0	-23.5	0.50
DETECTOR	1030302	1	1	0	2.2	2.2	2.2	0.0	0.0	-24.0	0.0	23.5	0.50
NUT DAMPER	1030401	13	1	0	3082.0	5472.7	6512.5	0.0	0.0	14.0	0.0	0.0	13.00
ATT COIL	1030402	13	1	0	1950.7	1950.7	3901.5	0.0	0.0	0.0	0.0	7.5	6.00
MOMENT COIL	1030500	13	1	0	12726.5	7470.0	7470.0	0.0	0.0	13.0	0.0	0.0	31.00
PITCH DAMPER	1030600	13	1	0	4231.2	4231.2	8458.7	0.0	0.0	0.0	0.0	-10.5	13.00
UPPER SOL AR	1040100	13	1	0	10116.6	10116.6	15901.3	0.0	0.0	0.0	0.0	-17.1	28.78
LOWER SOL AR	1040200	13	1	0	10116.6	10116.6	15901.3	0.0	0.0	0.0	0.0	17.1	28.78
BATT 1	1040301	1	1	0	5.5	11.3	4.8	0.0	0.0	-17.7	7.5	11.1	21.73
BATT 2	1040302	1	1	0	11.3	5.5	4.8	0.0	0.0	-1.0	-20.7	11.1	21.73
PWR SUPL EL	1041400	1	1	0	14.6	7.5	8.8	0.0	0.0	0.6	20.2	-13.1	22.60
ME-NST /PNDR	1050200	1	1	0	7.8	5.5	3.5	0.0	0.0	11.0	0.0	10.5	3.60
XPONDR CABLE	1050300	1	1	0	7.8	5.5	3.5	0.0	0.0	11.0	9.0	10.5	2.30
MG SN ANT.SB	1050400	4	1	0	0.0	0.0	3.5	1.0	0.0	-10.0	6.0	-74.5	1.40
ANT MAST.SA	1050500	12	1	1	0.0	0.0	50.0	0.5	0.0	-10.0	13.0	-40.0	1.00
S-FLT XTENK	1050600	1	1	0	5.5	7.8	3.5	0.0	0.0	-4.6	-18.8	10.5	1.80
PREMOD PROC	1050900	1	1	0	4.7	6.5	3.8	0.0	0.0	-11.5	4.0	12.5	4.40
CTP	1051100	1	1	0	12.3	6.6	6.8	0.0	0.0	4.4	10.0	-13.1	0.10
CDU	1060200	1	1	0	9.2	6.9	8.8	0.0	0.0	-8.7	12.6	13.1	10.80
RTM	1060300	1	1	0	9.9	7.2	8.8	0.0	0.0	1.8	14.2	13.1	6.40
TP RCRDR1	1060401	1	1	0	17.0	9.6	6.0	0.0	0.0	-15.1	7.5	-11.8	17.00
TP RCRDR2	1060402	1	1	0	13.0	9.0	6.0	0.0	0.0	-15.2	-4.1	-11.8	17.00
S/C HARNESS	1070600	4	1	0	0.0	0.0	45.5	25.0	0.0	0.0	0.0	0.3	64.70
SENSOR	1080101	1	1	1	6.0	6.0	6.0	0.0	0.0	7.1	30.3	-4.6	1.64
ELECTRONICS	1090102	1	1	0	8.5	7.0	7.6	0.0	0.0	7.2	-12.2	11.9	7.03
THRML BLNKT	1090103	1	1	0	8.5	7.0	7.4	0.0	0.0	7.2	-12.2	11.9	0.0
PREAMPS	1090201	1	1	1	1.3	3.8	2.5	0.0	0.0	1.8	17.5	0.0	0.33
PREAMPS	1090201	1	1	1	1.3	3.8	2.5	0.0	0.0	-1.8	-17.5	0.0	0.33
PREAMPS	1090201	1	1	0	3.8	1.3	2.5	0.0	0.0	0.0	-2.7	-12.9	0.33
PREAMPS	1090201	1	1	0	3.8	1.3	2.5	0.0	0.0	0.0	2.7	-12.9	0.33
ELECTRONICS	1090202	1	1	0	12.0	12.0	7.5	0.0	0.0	0.0	-14.9	-12.5	21.35
SHORT EL ANT	1090204	12	1	1	24.0	0.0	0.0	0.1	0.0	-243.0	114.0	0.0	0.15
SH EL ANT EL	1090205	1	1	1	3.3	4.8	1.5	0.0	0.0	-240.0	113.0	0.0	0.42
SEARCH COIL	1090206	12	1	0	0.0	0.0	16.0	0.4	0.0	-244.0	116.0	0.0	0.30
SRCH COIL EL	1090207	1	1	1	1.3	1.3	2.8	0.0	0.0	-244.0	116.0	0.0	0.32
LOOP ANTENNA	1090208	4	1	0	0.0	0.0	45.0	0.4	0.0	-253.0	118.3	0.0	0.27
LOOP ANTENNA	1090208	4	1	0	0.0	0.0	45.0	0.4	0.0	-287.0	124.3	0.0	0.27
LOOP ANTENNA	1090209	3	1	1	0.0	35.0	0.0	0.4	0.0	-271.3	121.3	22.5	0.68
LOOP ANTENNA	1090209	3	1	1	0.0	35.0	0.0	0.4	0.0	-271.3	121.3	-22.5	0.68
VIS SENSOR	1090301	13	1	1	461.0	627.1	555.5	0.0	0.0	-14.2	-13.3	0.4	11.34
VIS SENSOR	1090301	13	1	0	461.0	627.1	555.5	0.0	0.0	18.0	6.3	-0.4	11.34
VIR SENSOR	1090302	13	1	1	461.0	627.1	555.5	0.0	0.0	-4.4	10.0	[illegible]	11.34
DCU	1090304	1	1	0	3.8	1.6	5.3	0.0	0.0	8.4	8.5	6.1	1.80
ELECTRONICS	1090401	1	1	0	6.3	7.9	5.5	0.0	0.0	-11.6	-14.6	-11.5	9.00
DET ASSY	1090402	3	1	1	3.0	7.5	0.0	3.3	0.0	-20.4	-11.4	-3.0	7.00
HVPS	1090403	1	1	0	6.3	7.9	5.5	0.0	0.0	-11.6	-14.6	-11.5	1.50
FPS	1090404	1	1	0	6.3	7.9	5.5	0.0	0.0	-11.6	-14.6	-11.5	3.00
RAD SHLD	1090405	3	1	1	0.0	7.5	0.0	3.3	0.0	-20.4	-11.4	-3.0	1.00
CABLING	1090406	1	1	0	6.3	7.9	5.5	0.0	0.0	-11.6	-14.6	-11.5	0.50
ELECTRONICS	1090501	1	1	0	5.3	7.8	5.3	0.0	0.0	21.4	-1.5	-11.9	6.00
SENSOR	1090502	1	1	0	5.3	7.8	5.2	0.0	0.0	22.0	-0.8	-18.5	7.50
SENSOR	1090502	1	1	0	5.3	7.8	5.2	0.0	0.0	22.0	-0.8	18.5	7.50
SENSOR	1090502	1	1	1	5.0	7.8	5.7	0.0	0.0	20.1	16.7	-10.8	7.50
EIC	1091600	13	1	0	228.1	440.3	518.7	0.0	0.0	-15.1	-6.0	13.0	10.00
TUBE ANTENNA	1090701	12	1	0	0.0	0.0	118.1	0.6	0.0	0.0	0.0	81.6	0.48
TUBE ANTENNA	1090701	12	1	0	0.0	0.0	118.1	0.6	0.0	0.0	0.0	-81.6	0.48
DISPENSER	1090702	13	1	0	193.8	167.3	47.9	0.0	0.0	0.0	0.0	7.2	7.72
DISPENSER	1090702	13	1	0	193.8	167.3	47.9	0.0	0.0	0.0	0.0	-7.2	7.72
INBRD WIRE	1090801	2	1	1	2822.8	0.0	0.0	0.1	0.0	249.7	1416.1	0.6	0.16
INBRD WIRE	1090801	2	1	1	2822.8	0.0	0.0	0.1	0.0	-249.7	-1416.1	0.6	0.16

OUTBD WIRE	1990802	2	1	1	1114.2	9.0	0.0	0.1	0.0	346.4	1964.7	0.0	0.05
OUTBD WIRE	1990802	2	1	1	1114.2	0.0	0.0	0.1	0.0	-346.4	-1964.7	0.0	0.05
TIP MASS	1990803	5	1	0	0.0	0.0	0.0	0.1	0.0	446.2	2513.3	0.0	0.01
TIP MASS	1990803	5	1	0	0.0	0.0	0.0	0.1	0.0	-446.2	-2513.3	0.0	0.01
DISPENSER	1990804	1	1	1	9.8	7.3	5.5	0.0	0.0	-6.0	-20.0	0.0	5.28
DISPENSER	1990804	1	1	1	9.8	7.3	5.5	0.0	0.0	-6.0	-20.0	0.0	5.28
PWI SUBASSY	1 90901	11	1	1	0.0	12.0	0.0	0.5	0.0	-242.0	114.0	0.0	0.99
PWI MIXER	1 90902	1	1	1	2.0	5.0	3.3	0.0	0.0	-250.0	117.0	0.0	1.10
S/C BALANCE	1190100	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.35
MAG BAL	1190200	3	1	1	0.0	0.5	0.0	4.5	0.0	237.0	-110.5	0.0	7.65
MAST	1300101		1	1	232.6	0.0	0.0	4.5	0.0	-130.0	60.6	0.0	2.32
ASTRO MOUNT	1300102	2	1	1	15.0	0.0	0.0	5.0	0.0	-17.6	-8.6	0.0	11.68
MAST	1300201	2	1	1	0.0	232.0	0.0	4.5	0.0	130.0	-60.6	0.0	2.32
ASTRO MOUNT	1300202	2	1	1	15.0	0.0	0.0	5.0	0.0	17.6	-8.6	0.0	11.68
HARNESS.MAG	1300300	2	1	1	255.0	0.0	0.0	0.1	0.0	-130.0	60.6	0.0	6.58
HARNESS.MAG	1300400	3	1	1	0.0	255.0	0.0	0.1	0.0	130.0	-60.6	0.0	1.60

DYNAMICS EXPLORER DE-A
MOMENT OF INERTIA CALCULATIONS
BOX INERTIA VALUES

NAME	IXX	IYY	IZZ	TYPE
UPPER BP	4145.879	4145.879	8291.000	13
LOWER BP	4145.879	4145.879	8291.000	13
CENTER COL	480.340	480.340	354.320	13
SHR PANL 1	56.[illegible]	121.246	64.33[illegible]	1
SHR PANL 2	56.920	129.632	72.116	1
SHR PANL 3	56.920	129.632	72.116	1
SHR PANL 4	56.921	121.534	64.619	1
SHR PANL 5	56.920	129.632	72.116	1
SHR PANL 6	56.920	129.632	72.116	1
SEP ADPT UPR	1264.[illegible]	1264.560	5[illegible]3.300	13
SEP ADPT LWR	1366.260	1366.260	549.300	13
SIDES MU	6138.762	6138.762	11934.547	9
END MU	134.684	134.684	1660.181	9
SIDES ML	6138.762	6138.762	10934.547	9
END ML	134.688	134.688	1660.181	9
CENTER [illegible]	5419.406	5419.406	1121[illegible].816	9
[illegible]	819.[illegible]	819.39[illegible]	727.513	4
COVERS [illegible]ALS	1376.574	1376.574	1325.021	4
LIFTING [illegible]	229.429	229.429	220.503	4
[illegible]	455.512	455.512	632.014	4
HINGE MECH	1.363	1.281	1.281	1
LAUNCH SUPPT	0.625	0.625	1.000	1
RELEASE NO.2	0.417	0.417	0.667	1
ATC BRACKETS	0.2[illegible]2	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.2[illegible]2	0.202	0.377	4
ATC BRACKETS	0.2[illegible]	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
ATC BRACKETS	0.202	0.202	0.377	4
THM-UPR MAT	1502.532	1502.532	2332.061	9
ATC-UPR MAT	4.389	4.389	8.752	4
ATC-UPR MAT	4.389	4.389	8.752	4
ATC-UPR MAT	4.389	4.389	8.752	4
ATC-UPR MAT	4.389	4.389	8.752	4
ATC-UPR MAT	4.389	4.389	8.752	4
ATC-UPR MAT	4.389	4.389	8.752	4
THM-LWR MAT	1502.532	1502.532	2332.061	9
ATC-LWR MAT	4.389	4.389	8.752	4
ATC-LWR MAT	4.389	4.389	8.752	4
ATC-LWR MAT	4.389	4.389	8.752	4
ATC-LWR MAT	4.389	4.389	8.752	4
ATC-LWR MAT	4.389	4.389	8.752	4
ATC-LWR MAT	4.389	4.389	8.752	4
TEMP SENS-UP	0.0	0.0	0.0	1
TEMP SENS-LW	0.0	0.0	0.0	1
TM HEATERS	0.0	0.0	0.0	1
BOX MAG SENS	11.365	8.860	12.635	1

DETECTOR	0.403	0.403	0.403	1
DETECTOR	0.403	0.403	0.403	1
NUT DAMPER	5042.100	5872.699	6512.500	13
ATT COIL	1950.750	1950.750	3901.500	13
SGMENT COIL	12726.500	7470.000	7470.000	13
PITCH DAMPER	4231.139	4231.193	8458.730	13
UPPER SOL AR	10116.602	10116.602	15901.301	13
LOWER SOL AR	10116.602	10116.602	15901.301	13
BATT 1	272.570	96.366	285.606	1
BATT 2	96.366	272.570	285.608	1
PWR SUPL EL	201.743	547.296	507.309	1
HF-MSL XPNDR	30.217	46.293	57.690	1
XPONDR CABLE	8.146	14.009	17.459	1
MC ON ANT.SR	1.779	1.779	0.700	4
ANT MAST.SR	204.456	204.458	0.250	12
S-FLT NTWRK	10.953	6.375	13.663	1
PREMOD PROC	20.549	13.256	23.591	1
CIU	93.791	173.450	149.730	1
CDU	112.545	145.472	115.025	1
RTM	113.456	67.535	92.575	1
TP RCRDR1	165.750	290.417	354.167	1
TP RCRDR2	165.750	290.417	354.167	1
S/C HAR ESS	21027.492	21027.492	24218.742	4
SELSOA	9.000	9.000	9.440	1
ELECTRONICS	62.561	76.186	71.052	1
THRML BLNKT	0.0	0.0	0.0	1
PREAMPS	1.569	0.218	0.444	1
PREAMPS	0.569	0.218	0.444	1
PREAMPS	0.218	0.569	0.444	1
PREAMPS	0.218	0.569	0.444	1
ELECTRONICS	356.278	356.278	512.400	1
SHORT EL ANT	0.063	7.201	7.201	10
SH EL ANT EL	1.088	0.452	1.176	1
SEARCH COIL	6.421	6.421	0.042	12
SRCH COIL EL	0.254	0.254	0.590	1
LOOP ANTENNA	146.347	146.347	0.070	4
LOOP ANTENNA	146.347	146.347	0.570	4
LOOP ANTENNA	69.444	9.454	69.444	3
LOOP ANTENNA	69.444	3.454	69.444	3
VIS SENSOR	450.480	627.100	555.480	13
VIS SENSOR	450.980	627.100	555.480	13
XUV SENSOR	432.230	627.160	555.480	13
DCU	4.549	6.379	2.652	1
ELECTRONICS	49.495	52.455	75.575	1
DET ASSY	31.237	36.964	41.297	3
HVPS	11.592	8.742	12.762	1
PFS	23.153	17.485	25.525	1
RAD SHLD	7.322	5.281	7.328	3
CABLING	3.861	2.914	4.254	1
ELECTRONICS	43.613	27.563	47.813	1
SENSOR	40.325	34.456	55.581	1
SENSOR	34.925	34.456	55.581	1
SENSOR	40.796	32.852	53.164	1
EIC	278.120	440.420	518.690	13
TUBE ANTENNA	558.075	558.075	0.153	12
TUBE ANTENNA	558.075	558.075	0.153	12
DISPENSER	193.800	167.300	47.900	13
DISPENSER	193.800	167.300	47.900	13
INBRD WIRE	0.001	106244.875	106244.875	2
INBRD WIRE	0.001	106246.375	106246.375	2

OUTRD WIRE	0.000	5172.391	5172.391	2
OUTRD WIRE	0.000	5172.391	5172.391	2
TIP MASS	0.000	0.000	0.000	5
TIP MASS	0.000	0.000	0.000	5
DISPENSER	36.747	65.066	65.668	1
DISPENSER	36.747	65.066	65.668	1
PWI SUBASSY	16.912	0.925	16.912	11
PWI MINUS	3.117	1.192	2.658	1
S/C BALANCE	112.933	112.933	112.933	1
MAG PAL	54.887	77.456	36.887	3
MAST	23.498	10417.711	10417.711	2
ASTRO MOMR	146.000	292.000	292.000	2
MAST	10417.711	23.498	10417.711	3
ASTRO MOMR	146.000	292.000	292.000	2
HARNESS.PWI	0.956	35221.898	35221.898	2
HARNESS.MAG	9673.008	0.814	9670.008	3

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OF POOR QUALITY

DYNAMICS EXPLORER DE-A
MOMENT OF INERTIA CALCULATIONS
BOX AXIS ROTATION FOR NONPARALLEL AXES

NAME	IXX	IYY	IZZ	IXY	IXZ	IYZ	ANG1	ANG2	ANG3	ANG4
UPPER RP	4145.879	4145.879	8291.000							
LOWER RP	4145.879	4145.879	8291.000							
CENTER COL	440.346	440.347	354.320							
SHR PANL 1	56.321	121.146	64.339	0.040	-0.000	0.000	180.0	270.0	90.0	90.0
SHR PANL 2	56.320	129.032	72.116							
SHR PANL 3	111.330	74.948	72.116	31.225	0.000	-0.000	60.0	150.0	90.0	90.0
SHR PANL 4	56.021	121.334	64.619	-0.000	0.000	-0.000	0.0	90.0	90.0	90.0
SHR PANL 5	86.408	131.460	50.387	-31.225	0.000	-0.000	180.0	60.0	90.0	90.0
SHR PANL 6	111.330	74.948	72.116	31.225	-0.000	0.000	240.0	330.0	90.0	90.0
SEP ADPT UPR	1264.360	1264.360	553.300							
SEP ADPT LWR	1346.360	1346.361	553.310							
SIDES MU	6036.762	6036.762	10934.547							
END MU	834.588	834.588	1669.181							
SIDES ML	6036.762	6036.762	10934.547							
END ML	834.588	834.588	1669.181							
CENTER RING	5619.476	5619.476	11214.814							
ERKTS,MISC	819.530	819.393	787.513							
COVERS+SEALS	1376.574	1375.574	1323.021							
LIFTING HDWE	[illegible]	224.429	224.527							
HOUSE,ASSY	655.512	655.512	630.814							
HINGE MECH	1.503	1.281	1.281							
LAUNCH SUPPT	0.525	0.625	1.000							
RELEASE MCHS	0.317	0.417	0.667							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.222	0.222	0.377							
THR-UPR HAT	1382.532	1382.532	2332.061							
ATC-UPR HAT	4.389	4.389	8.752							
ATC-UPR HAT	4.389	4.389	8.752							
ATC-UPR HAT	4.389	4.389	8.752							
ATC-UPR HAT	4.389	4.389	8.752							
ATC-UPR HAT	4.389	4.389	8.752							
ATC-UPR HAT	4.389	4.389	8.752							
THR-LWR HAT	1382.532	1382.532	2332.061							
ATC-LWR HAT	4.389	4.389	8.752							
ATC-LWR HAT	4.389	4.389	8.752							
ATC-LWR HAT	4.389	4.389	8.752							
ATC-LWR HAT	4.389	4.389	8.752							
ATC-LWR HAT	4.389	4.389	8.752							
ATC-LWR HAT	4.389	4.389	8.752							
TEMP SENS-UP	0.0	0.0	0.0							
TEMP SENS-LP	0.0	0.0	0.0							
TH HEATERS	0.0	0.0	0.0							
BDY HOR SENS	11.273	9.157	12.625	-0.803	-0.000	0.000	20.0	110.0	90.0	90.0

DETECTOR	0.403	0.403	0.403						
DETECTOR	0.403	0.403	0.403						
NUT DAMPER	[illegible]	5472.693	4512.502						
ATT COIL	1930.750	1350.759	3901.566						
MOMENT COIL	12726.566	7470.760	7470.600						
PITCH DAMPER	4231.199	4231.199	2454.730						
UPPER SOL AR	19116.002	19116.002	15961.301						
LOWER SOL AR	19116.002	19116.002	15961.301						
BATT 1	272.579	56.366	235.604						
BATT 2	[illegible]	272.579	262.604						
P&P SUPL EL	[illegible]	547.245	527.370						
[illegible]	26.417	66.293	57.650						
XPONDR CABLE	8.146	14.099	17.459						
MD SN ALT.SE	1.779	1.779	0.700						
A.T HASI.SL	[illegible]	140.143	20.6[illegible]	-6.000	-0.200	66.017	0.0	90.0	90.0 116.0
SAFELT STUNT	12.353	5.375	13.665						
PREMOD PROC	[illegible]	13.256	23.591						
CIE	6.711	173.454	144.704						
[illegible]	[illegible]	[illegible]	11[illegible]						
PTM	117.436	87.035	92.575						
TP ACRDR1	105.7.0	290.415	354.167						
TP ACRDR	[illegible]	290.417	354.177						
S/C HAR [illegible]SS	21 7.432	21127.492	21216.742						
SENSOR	[illegible]	9.463	7.531	-4.536	0.466	-0.006	14.0	264.0	90.0 56.0
ELECTRONICS	[illegible]	73.186	71.059						
THERML [illegible]	[illegible]	[illegible]	[illegible]						
PREAMPS	[illegible]	[illegible]	[illegible]						
PREAMPS	[illegible]	0.296	0.444	-6.145	-6.000	0.000	30.0	116.0	90.0 90.0
PREAMPS	[illegible]	0.369	0.444	-6.145	-6.000	0.000	26.0	116.0	90.0 90.0
PREAMPS	[illegible]	0.369	0.444						
ELECTRONICS	[illegible]	356.778	512.400						
SHORT EL ANT	[illegible]	0.720	7.201	1.231	0.000	0.000	86.0	170.0	90.0 90.0
SH EL A.T.[illegible]	[illegible]	[illegible]	1.176	-6.147	-0.000	0.006	65.0	155.0	90.0 90.0
SEARCH COIL	6.421	6.421	0.042						
SRCH COIL EL	[illegible]	3.254	0.040	-6.000	0.000	-0.000	65.0	155.0	90.0 90.0
LOOP ANTENNA	146.347	146.347	0.076						
LOOP ANTENNA	146.347	146.347	0.070						
LOOP ANTENNA	2.147	67.351	69.444	-11.866	-0.000	0.000	80.0	170.0	90.0 90.0
LOOP ANTENNA	2.147	67.351	69.444	-11.866	-0.000	0.000	80.0	170.0	90.0 90.0
VIS SENSOR	530.453	523.517	555.479						
VIS SENSOR	4[illegible]	527.130	555.409	81.798	-0.000	-0.000	230.0	320.0	90.0 90.0
VUV SENSOR	[illegible]	484.412	566.440	-53.306	0.000	0.000	110.0	206.0	90.0 90.0
DPU	[illegible]	6.379	7.652						
ELECTRONICS	59.415	52.455	76.575						
DET ASSY	47.716	40.551	51.297	-6.204	-0.000	0.000	30.0	180.0	90.0 90.0
HVES	11[illegible]	[illegible].742	12.762						
PPS	75.1[illegible]	17.465	25.525						
RAD SHLD	[illegible]	[illegible].793	7.320	-0.006	-0.000	0.000	30.0	186.0	90.0 90.0
CABLING	5.[illegible]41	2.014	4.254						
ELECTRONICS	[illegible]3.[illegible]13	27.565	47.613						
SENSOR	[illegible]	30.456	66.561						
SENSOR	[illegible]	34.455	55.561						
SENSOR	49.[illegible]	27.681	55.164	-9.004	-0.000	0.000	28.0	116.0	90.0 90.0
EIC	[illegible]	448.320	510.620						
TUBE ANTENNA	550.675	550.675	[illegible].153						
TUBE ANTENNA	550.675	556.675	2.153						
DISPENSER	1[illegible]3.[illegible]	167.300	47.900						
DISPENSER	1[illegible]3.[illegible]	167.300	47.900						
INBRD WIRE	1[illegible]1.1[illegible]	3263.695	1[illegible]6244.875	18168.992	0.006	0.033	80.0	170.0	90.0 90.0
INBRD WIRE	103[illegible]	3263.740	10[illegible]244.375	18168.242	0.306	0.033	80.0	170.0	90.0 90.0

OUTBRD WIRE	5316.918	155.766	5172.391	884.533	0.000	0.002	80.0	170.0	90.0	90.0
OUTBRD WIRE	5315.418	155.768	5172.391	884.533	0.000	0.002	80.0	170.0	90.0	90.0
TIP MASS	[illegible]	[illegible]	[illegible]							
TIP MASS	[illegible]	[illegible]	0.000							
DISPENSER	50.359	37.304	65.658	3.215	-0.000	0.000	85.0	170.0	90.0	90.0
DISPENSER	50.359	37.304	65.668	3.215	-0.000	0.000	80.0	170.0	90.0	90.0
PWI SUBASSY	2.134	[illegible]	10.912	-4.[illegible]	-0.000	0.000	65.0	155.0	90.0	90.0
P.I WIRE	1.[illegible]	[illegible].773	[illegible].670	-[illegible].777	-0.000	0.000	65.0	155.0	90.0	90.0
S/C BALANCE	112.[illegible]	11[illegible].433	112.933							
MAG BAL	[illegible]	4[illegible].776	3[illegible].887	14.773	0.000	-0.000	65.0	155.0	90.0	90.0
MAST	1[illegible]	[illegible]61.239	1[illegible]417.783	-3991.217	-0.003	0.001	155.0	245.0	90.0	90.0
ASTRO MASP	17[illegible]	[illegible]23	242.060	[illegible].321	-0.000	0.000	155.0	245.0	90.0	90.0
MAST	1975.[illegible]6	8561.239	10417.703	-3981.219	-0.003	0.001	65.0	155.0	90.0	90.0
ASTRO MASP	[illegible].[illegible]23	172.[illegible]76	292.000	55.921	0.000	0.000	65.0	155.0	90.0	90.0
HARNESS.2ND	[illegible]	[illegible]431.047	35221.883	-13490.750	-0.010	0.005	155.0	245.0	90.0	90.0
HARNESS.MAS	1[illegible]48.[illegible]32	7121.440	4670.900	-3320.[illegible]3	-0.[illegible]92	0.001	65.0	155.0	90.0	90.0

DYNAMICS EXPLORER DE-A
MOMENT OF INERTIA CALCULATIONS ABOUT S/CAXIS

AN ASTERISK INDICATES THE TOTAL SUM OF THE MOMENTS OF BOX COMPONENTS

ID	NAME	IXX	IYY	IZZ
[illegible]	[illegible]	5828.5781	[illegible].5781	8291.[illegible]
[illegible]	[illegible]	5785.4336	5785.4336	8281.6080
1311391	CENTER COL	481.3401	460.3401	354.3201
[illegible]	SHR PANL 1	56.9212	680.7525	623.4479
[illegible]	SHR PANL 2	561.2340	277.[illegible]	666.[illegible]
1311314	SHR PANL 3	555.3216	223.3158	664.8019
1313315	SHR PANL 4	56.9212	680.6509	623.7354
[illegible]	SHR PANL 5	650.8059	247.6315	646.7720
[illegible]	SHR PANL [illegible]	555.3216	223.3158	664.8[illegible]
[illegible]	SEC SUPT UPR	5475.6406	5475.6406	553.3[illegible]
[illegible]	SEC SUPT LWR	5832.6682	5832.6682	688.3660
[illegible]	[illegible]	3491.6828	3491.6828	10934.[illegible]
[illegible]	[illegible]	3136.8760	3136.8760	1165.1814
[illegible]	SLIPS HL	8491.8828	8491.8828	10934.6464
[illegible]	[illegible] HL	3036.8760	3036.8760	1169.1814
[illegible]	[illegible] RING	5619.4062	5619.4062	11214.8164
[illegible]	[illegible]	313.3896	313.3896	787.5137
[illegible]	[illegible]	1376.5745	1376.5745	1323.0215
1311336	LIFTING HOWS	229.4291	229.4291	220.5034
1311566	[illegible]	655.5117	655.5117	630.0103
1311661	[illegible]	1521.9625	944.7812	277.2812
[illegible]	LAUNCH [illegible]	754.1250	944.1250	151.0000
1311603	RELEASE [illegible]	1258.0165	629.0165	430.6665
[illegible]	ATC BRACKETS	144.3358	228.1905	104.4990
1311790	ATC BRACKETS	231.0171	138.[illegible]	131.2956
[illegible]	ATC BRACKETS	178.7371	193.4682	108.1780
[illegible]	ATC BRACKETS	145.3558	219.5621	130.2906
[illegible]	ATC BRACKETS	236.7958	137.2171	105.9856
1311700	ATC BRACKETS	178.5058	138.2171	101.2956
[illegible]	ATC BRACKETS	144.3358	228.1905	104.4990
[illegible]	ATC BRACKETS	231.0171	138.5358	131.2956
1311800	ATC BRACKETS	178.7371	193.4682	108.1780
[illegible]	ATC BRACKETS	149.3558	219.5621	120.2906
[illegible]	ATC BRACKETS	236.7958	137.2171	105.9856
[illegible]	ATC BRACKETS	178.5058	191.[illegible]	101.2956
[illegible]	THR-UPR HAT	1712.0417	1712.0417	2332.0605
[illegible]	ATC-UPR HAT	147.6627	231.6167	112.2522
[illegible]	ATC-UPR HAT	233.8264	141.4687	188.0679
[illegible]	ATC-UPR HAT	177.8624	196.4937	107.9499
[illegible]	ATC-UPR HAT	151.6587	222.[illegible]374	103.0689
[illegible]	ATC-UPR HAT	139.5767	14[illegible]	113.7300
[illegible]	ATC-UPR HAT	181.6287	193.6664	109.0679
[illegible]	THR-LWR HAT	1712.0417	1712.0417	2332.0605
[illegible]	ATC-LWR HAT	147.6627	231.6167	112.2522
[illegible]	ATC-LWR HAT	233.8264	141.4687	189.0679
[illegible]	ATC-LWR HAT	177.8824	196.4937	107.9496
[illegible]	ATC-LWR HAT	151.6587	222.4374	108.0689
[illegible]	ATC-LWR HAT	239.5787	140.5864	113.7299
[illegible]	ATC-LWR HAT	181.6287	193.6664	109.0679
1020301	TEMP SENS-UM	18.3750	18.3750	0.0
[illegible]	TEMP SENS-LB	18.3750	18.3750	0.0
[illegible]	TH HEATERS	0.0	0.0	0.0
[illegible]	[illegible] HOR SENS	1062.6923	287.1330	1560.[illegible]

1530302	D_TECTOR	276.5283	564.5283	288.4033
153[illegible]302	[illegible]TECTO[illegible]	276.5283	564.[illegible]283	288.4033
1530801	[illegible]	[illegible]	[illegible]	[illegible]
153[illegible]402	[illegible] COIL	2288.2550	2266.2595	3961.5806
153[illegible]	[illegible]T COIL	12726.5090	12765.[illegible]390	12789.0889
[illegible]	[illegible] DAMPER	2686.8892	[illegible]8892	8834.7306
154.1[illegible]	[illegible] SPL A[illegible]	14522.3044	1[illegible]522.7044	15[illegible]1.5[illegible]
154.20[illegible]	[illegible] A[illegible]	[illegible]	1[illegible]22.[illegible]86	15[illegible]1.[illegible]
1541[illegible]	[illegible] 1	8[illegible].9863	[illegible]	8384.[illegible]172
154[illegible]302	[illegible]	12092.3789	2[illegible]92.[illegible]671	9[illegible]5.5312
15[illegible]	[illegible]PL [illegible]L	[illegible]41.5273	4463.[illegible]405	9737.2187
15[illegible]	[illegible]	[illegible]	[illegible]	1731.[illegible]
15[illegible] 390	[illegible] CABLE	448.0269	587.[illegible]357	524.5187
1550[illegible]	[illegible] AIT.SR	7824.5234	7912.1250	1[illegible]1.[illegible]
[illegible]	[illegible] MAST.SR	2654.7263	[illegible]	[illegible]
[illegible]	[illegible]	84[illegible].6752	[illegible]	[illegible]7.1194
[illegible]	[illegible]	775.[illegible]	1282.[illegible]	[illegible]75.[illegible]11
[illegible]	[illegible]	2953.[illegible]	1695.[illegible]	1436.[illegible]
[illegible]	[illegible]	3694.7146	[illegible]831.[illegible]765	2651.[illegible]947
[illegible]	[illegible]	32[illegible]9.7786	1567.[illegible]996	1[illegible]13.[illegible]67
[illegible]	[illegible]	34[illegible]2.0625	6513.[illegible]	51[illegible].[illegible]
[illegible] 412	T[illegible]	2798.5823	6565.1523	4567.6133
[illegible]	[illegible]	21[illegible]27.4922	21027.4922	20218.74[illegible]
[illegible]	[illegible]	1517.[illegible]616	[illegible]	1[illegible]3.[illegible]
1[illegible]2	LECTRONICS	2155.0051	1436.[illegible]259	1482.2337
1[illegible]	THRML [illegible]	[illegible]	1[illegible]	[illegible]
[illegible]	[illegible]	101.5502	1.3648	102.[illegible]
[illegible]	[illegible]	101.5502	1.3648	102.5753
[illegible]	[illegible]	47.5393	55.4843	2.8493
[illegible]	[illegible]	57.5393	55.4843	2.[illegible]
1[illegible]	LECTRONICS	8432.1250	5692.[illegible]161	5252.3125
[illegible]	[illegible] EL ANT	1956.3234	[illegible]57.[illegible]664	10[illegible]13.94[illegible]
199.235	[illegible]	5363.9258	[illegible]193.[illegible]266	29556.1662
[illegible]	[illegible] COIL	4[illegible]47.22[illegible]	17967.2148	21897.6367
[illegible] 2.[illegible]	[illegible] COIL EL	43[illegible].1719	1[illegible]951.7734	23357.5273
[illegible]	LOOP ANTENNA	12322.[illegible]	56187.1062	68216.1250
[illegible]	LOOP ANTENNA	13588.7656	72207.[illegible]750	855[illegible]3.0008
[illegible]	LOOP ANTENNA	1[illegible]351.6942	5[illegible]462.1055	60125.2539
1899239	LOOP ANTENNA	1[illegible]351.6992	59462.1055	60125.2539
1[illegible]301	VIS S[illegible]NSOR	2565.9834	2817.7931	4[illegible]46.4883
1[illegible]301	VIS [illegible]	913.2012	4302.2578	4678.2656
[illegible]	[illegible]	4752.2578	[illegible]7.2126	4862.2734
1[illegible]39[illegible]	D[illegible]	2[illegible]1.7275	2[illegible]3.3654	259.7097
[illegible]	LECTRONICS	[illegible]17[illegible].1[illegible]41	[illegible]453.7432	32[illegible].6547
[illegible]	[illegible] ASSY	1355.8718	3252.1057	3874.1348
1[illegible]493	[illegible]	529.6978	466.[illegible]575	534.3423
[illegible]	[illegible]	1[illegible]54.3945	817.[illegible]143	1[illegible]68.[illegible]
[illegible]	[illegible] SHLD	150.[illegible]389	636.[illegible]151	553.[illegible]75
1[illegible]	CABLI[illegible]	176.5658	136.3191	176.2142
[illegible]	LECTRONICS	9[illegible].9724	[illegible]624.[illegible]808	2[illegible]5.[illegible]
1[illegible]502	S[illegible]SOR	2626.0186	6231.[illegible]281	3[illegible].7[illegible]
1[illegible]	[illegible]SOR	2626.0186	6231.3281	3[illegible]9.7[illegible]
1[illegible]502	[illegible]	1775.32[illegible]1	3934.4751	3[illegible]1.[illegible]13[illegible]
[illegible]	[illegible]	[illegible]	7832.1797	95[illegible].7[illegible]
1[illegible]701	TUBE ANTENNA	3751.0503	3731.0503	0.1532
1[illegible]701	TUBE ANTENNA	3751.0503	3751.0503	0.1532
1[illegible]702	DISPENSER	590.0844	567.5844	47.4900
1[illegible]702	DISPENSER	594.0844	567.5944	47.9960
1999891	INBRD WIRE	423895.375	13178.9102	437074.312
1[illegible]891	INBRD WIRE	423896.812	13178.9531	437075.812

1092802	OUTBOARD WIRE	198018.625	6156.6484	204175.250
1092802	OUTBOARD WIRE	198018.625	6156.6464	204175.250
1292633	TIP MASS	82116.7500	2553.0789	84669.8125
129[illegible]	TIP [illegible]	82116.7500	2553.0789	84669.8125
129[illegible]	DISPENSER	2165.7680	227.0756	2392.4397
1291000	DISPENSER	2165.7680	227.0756	2392.4397
1190001	[illegible] SUBASSY	11658.5312	52716.0977	64414.9962
1190002	[illegible] HINGE	15059.4375	68752.7560	83810.2100
1192133	S/C BALANCE	112.0333	112.0333	112.0333
11[illegible]2[illegible]	MAS BAL	93478.9375	429735.062	523140.062
130[illegible]1[illegible]1	MAST	1[illegible]309.8359	47769.2227	58145.5703
1301[illegible]2	ASTRO MONR	1238.6240	3883.0180	4773.8437
1300201	MAST	10399.8396	47769.2227	56145.5703
130[illegible]2[illegible]	ASTRO MOUN	1129.7759	3790.0730	4773.8437
1301[illegible]	[illegible]	30161.2422	136701.186	168043.187
130[illegible]	[illegible]S.M[illegible]	7924.3086	34161.4864	41585.7812

ORIGINAL PAGE IS
OF POOR QUALITY

DYNAMICS EXPLORER DE-A
S/C MOMENTS OF INERTIA
01 OCTOBER 1978 DEPLOYED

THE TOTALS BEFORE BALANCING ARE-

SUM OF WEIGHTS= 0.78497925E+03
SUM OF WEIGHT * X DISTANCE=-0.73439990E+03
SUM OF WEIGHT * Y DISTANCE= 0.27169336E+03
SUM OF WEIGHT * Z DISTANCE=-0.64699731E+03
SUM OF WEIGHT * X * Z DISTANCES=-0.11025671E+04
SUM OF WEIGHT * Y * Z DISTANCES=-0.51869961E+04
SUM OF WEIGHT * X * Y DISTANCES=-0.27835287E+06
SUM OF WEIGHT * X2= 0.11689820E+07
SUM OF WEIGHT * Y2= 0.14798090E+07
SUM OF WEIGHT * Z2= 0.10464394E+06

SUM OF IXX= 0.33477534E+06
SUM OF IYY= 0.16559812E+06
SUM OF IZZ= 0.43526012E+06

THE C.G. COMPONENTS ARE-- X= -0.940562E+00 Y= 0.346115E+00 Z= -0.824222E+00

SUM OF IXY= 0.13362957E+05
SUM OF IXZ=-0.64203603E-02
SUM OF IYZ= 0.06794202E+02

ORIGINAL PAGE IS OF POOR QUALITY

DYNAMICS EXPLORER DE-A
S/C MOMENTS OF INERTIA
01 OCTOBER 1978

S/C MOMENTS OF INERTIA ARE-

* THE FOLLOWING VALUES HAVE UNITS OF LB.-IN2
IX= 0.121853+0E+07
IY= 0.143729405+07
IZ= 0.308329205+07
IXZ=-0.171117425+04
IYZ=-0.439[illegible]25E+04
IXY=-0.2647342[illegible]+06
IMAX= 0.2335428[illegible]+07
IMIN= 0.132976[illegible]+07

* THE FOLLOWING VALUES HAVE UNITS OF IN-LBS-SEC2
IXX= 0.4963945[illegible]+04
IYY= 0.372[illegible]+04
IZZ= 0.79[illegible]+04
IYZ=-0.4452646[illegible]+01
IXZ=-0.1268278[illegible]+02
IXY=-0.6[illegible]+03
IMAX= 0.527351725+04
IMIN= 0.342131085+04

INERTIA RATIO

I /I = 1.515
SPIN/ TRANSVERSE MAX

APPENDIX C

DE-B STOWED MASS PROPERTIES

COMPUTER OUTPUT

DYANICS EXPLORER DE-B
SPACECRAFT CONFIGURATION REPORT SYSTEM
01 OCTOBER 1978

ID	DATE	NAME	DRWG.NO.	SOURCE	ZONE	PROPOSAL WEIGHT	TARGET WEIGHT	EST/ACT WEIGHT	%TOL	WT TOL	QTY
1000000	11 1 7	DE-B	2294700-501		1.	0.0	0.0	0.0	0.0	0.0	1.
1010000	5 1 8	STRUCTURE-R-			1.	136.90	165.80	0.0	0.0	0.0	1.
1010100	11 1 7	UPPER BP		AE-C	1.	0.0	0.0	23.400	0.0	0.0	1.
1010200	11 1 7	LOWER BP			1.	0.0	0.0	22.800	0.0	0.0	1.
1010300	11 1 7	CEN COL/SH P			1.	0.0	0.0	0.0	0.0	0.0	1.
1010301	11 1 7	CENTER COL			1.	0.0	0.0	9.200	0.0	0.0	1.
1010302	11 1 7	SHR PANL 1			1.	0.0	0.0	2.420	0.0	0.0	1.
1010303	11 1 7	SHR PANL 2			1.	0.0	0.0	2.420	0.0	0.0	1.
1010304	11 1 7	SHR PANL 3			1.	0.0	0.0	2.420	0.0	0.0	1.
1010305	11 1 7	SHR PANL 4			1.	0.0	0.0	2.420	0.0	0.0	1.
1010306	11 1 7	SHR PANL 5			1.	0.0	0.0	2.420	0.0	0.0	1.
1010307	11 1 7	SHR PANL 6			1.	0.0	0.0	2.420	0.0	0.0	1.
1010500	11 1 7	SEP ATPT LWR			1.	0.0	0.0	15.300	0.0	0.0	1.
1010600	A 1 8	HAT UPPER			1.	0.0	0.0	0.0	0.0	0.0	1.
1010601	A 1 8	SIDES HU			1.	0.0	0.0	15.700	0.0	0.0	1.
1010602	A 1 8	END HU			1.	0.0	0.0	4.350	0.0	0.0	1.
1010700	A 1 8	HAT LOWER			1.	0.0	0.0	0.0	0.0	0.0	1.
1010701	A 1 8	SIDES HL			1.	0.0	0.0	15.700	0.0	0.0	1.
1010702	A 1 8	END HL			1.	0.0	0.0	4.350	0.0	0.0	1.
1010800	3 1 6	CENTER WING			1.	0.0	0.0	0.0	0.0	0.0	1.
1010801	3 1 8	RING			1.	0.0	0.0	6.500	0.0	0.0	1.
1010802	3 1 8	BRACKETS			1.	0.0	0.0	9.500	0.0	0.0	1.
1010900	11 1 7	ANA SUPPT CO			1.	0.0	0.0	3.400	0.0	0.0	1.
1011000	11 1 7	HARDWARE			1.	0.0	0.0	1.000	0.0	0.0	1.
1011100	11 1 7	BRKTS,MISC			1.	0.0	0.0	2.500	0.0	0.0	1.
1011200	11 1 7	COVERS+SEALS			1.	0.0	0.0	4.200	0.0	0.0	1.
1011300	11 1 7	LIFTING HDWR			1.	0.0	0.0	1.200	0.0	0.0	1.
1011400	11 1 7	RF SCREENS			1.	0.0	0.0	0.300	0.0	0.0	4.
1011500	11 1 7	HDWRE BOX			1.	0.0	0.0	2.000	0.0	0.0	1.
1011600	1 1 6	ANTENNA SUPT			1.	0.0	0.0	0.0	0.0	0.0	1.
1011601	9 1 8	DUL GN BIPD			1.	0.0	0.0	1.500	0.0	0.0	1.
1011602	1 1 8	HI GN BRGTRY			1.	0.0	0.0	2.500	0.0	0.0	1.
1011700	9 1 8	ATC BRACKETS			1.	0.0	0.0	0.335	0.0	0.0	4.
1020000	5 1 8	THERMAL -R-			1.	10.40	10.50	0.0	0.0	0.0	1.
1020100	11 1 7	THR-UPR HAT			1.	0.0	0.0	0.0	0.0	0.0	1.
1020101	8 1 8	THR-UPR HAT			1.	0.0	0.0	3.750	0.0	0.0	1.
1020102	11 1 7	ATC-UPR HAT	2271611-503		1.	0.0	0.0	0.600	0.0	0.0	4.
1020300	11 1 7	THR-UPR B/P			1.	0.0	0.0	0.0	0.0	0.0	1.
1020301	A 1 8	TEMP SENS-UB			1.	0.0	0.0	0.240	0.0	0.0	1.
1020400	11 1 7	THR-LWR B/P			1.	0.0	0.0	0.0	0.0	0.0	1.
1020401	A 1 8	TEMP SENS-LB			1.	0.0	0.0	0.240	0.0	0.0	1.
1020402	8 1 8	THR-LWR B/P			1.	0.0	0.0	3.750	0.0	0.0	1.
1020500	11 1 7	TH HEATERS			1.	0.0	0.0	0.100	0.0	0.0	1.
1030000	5 1 8	ATT CONTR B			1.	99.70	100.10	0.0	0.0	0.0	1.
1030200	8 1 8	PITCH CON EL	2271623-501		1.	0.0	0.0	8.400	0.0	0.0	1.
1030300	A 1 8	SUN SENSOR			1.	0.0	0.0	0.0	0.0	0.0	1.
1030301	8 1 6	DETECTORS			1.	0.0	0.0	0.800	0.0	0.0	2.
1030302	A 1 8	ELECTRONICS			1.	0.0	0.0	1.100	0.0	0.0	2.
1030400	11 1 7	NUT DPR+COIL			1.	0.0	0.0	0.0	0.0	0.0	1.
1030401	11 1 7	NUT DAMPER			1.	0.0	0.0	16.400	0.0	0.0	1.

1038402	8	1	8	AYY COIL			1.	0.0	0.0	6.860	0.0	0.0	2.
1038500	8	1	8	PITCH COIL			1.	0.0	0.0	3.000	0.0	0.0	1.
1038760	8	1	8	MOM WHL ASSY			1.	0.0	0.0	0.0	0.0	0.0	1.
1038761	8	1	8	MOTOR ASSY			1.	0.0	0.0	22.300	0.0	0.0	1.
1038762	8	1	8	INERTIA WHL			1.	0.0	0.0	22.300	0.0	0.0	1.
1038803	11	1	7	WHL MOM SENS			1.	0.0	0.0	2.088	0.0	0.0	1.
1038960	11	1	7	MVA SHIELD			1.	0.0	0.0	2.400	0.0	0.0	1.
1040000	5	1	8	POWER			1.	120.18	127.10	0.0	0.0	0.0	1.
1040100	11	1	7	UPPER SOL AR	2294644-502		1.	0.0	0.0	0.0	0.0	0.0	1.
1040101	8	1	8	CELL MODULES			1.	0.0	0.0	26.090	0.0	0.0	1.
1040102	8	1	8	SHUNT WIRING			1.	0.0	0.0	2.850	0.0	0.0	1.
1040103	8	1	8	DIODES			1.	0.0	0.0	0.920	0.0	0.0	1.
1040200	11	1	7	LOWER SOL AR	2294744-502		1.	0.0	0.0	0.0	0.0	0.0	1.
1040201	8	1	8	CELL MODULES			1.	0.0	0.0	30.620	0.0	0.0	1.
1040202	8	1	8	SHUNT WIRING			1.	0.0	0.0	3.350	0.0	0.0	1.
1040203	8	1	8	DIODES			1.	0.0	0.0	1.080	0.0	0.0	1.
1040300	11	1	7	BATTERIES			1.	0.0	0.0	0.0	0.0	0.0	1.
1040301	3	1	6	BATT 1	2294642-501		1.	0.0	0.0	21.780	0.0	0.0	1.
1040302	3	1	6	BATT 2	2294642-501		1.	0.0	0.0	21.780	0.0	0.0	1.
1040400	11	1	7	PWR SUPL EL	2294640-501		1.	0.0	0.0	22.600	0.0	0.0	1.
1050000	5	1	8	CONNCTNS-B-			1.	24.36	33.20	0.0	0.0	0.0	1.
1050100	3	1	6	TORSS XDUCR	2295161-1		1.	0.0	0.0	15.900	0.0	0.0	1.
1050300	11	1	7	XDUCR CABLE			1.	0.0	0.0	2.300	0.0	0.0	1.
1050500	3	1	6	LOW GAIN ANT			1.	0.0	0.0	1.400	0.0	0.0	1.
1050600	3	1	6	HI. GAIN ANT			1.	0.0	0.0	7.100	0.0	0.0	1.
1050800	11	1	7	S/C FLT NTWRK			1.	0.0	0.0	2.100	0.0	0.0	1.
1050900	11	1	7	PREMOD PROC			1.	0.0	0.0	4.400	0.0	0.0	1.
1060000	5	1	8	C & DH			1.	53.10	62.30	0.0	0.0	0.0	1.
1060100	11	1	7	CTP	2294670-501		1.	0.0	0.0	9.100	0.0	0.0	1.
1060200	11	1	7	CDU	2294673-501		1.	0.0	0.0	10.800	0.0	0.0	1.
1060300	11	1	7	RTU	2294671-501		1.	0.0	0.0	8.400	0.0	0.0	1.
1060400	3	1	8	TAPE RECORDR		4.16.5-1	1.	0.0	0.0	17.000	0.0	0.0	2.
1080000	10	1	8	S/C HARNESS	2295147-502		1.	0.0	0.0	0.0	0.0	0.0	1.
1080100	10	1	8	UPPER HARN	2294647-502		1.	0.0	0.0	27.500	0.0	0.0	1.
1080200	10	1	8	LOWER HARN	2294747-502		1.	0.0	0.0	27.500	0.0	0.0	1.
1080300	10	1	8	GROUND BLOCK			1.	0.0	0.0	0.400	0.0	0.0	1.
1080400	11	1	7	GROUND BLOCK			1.	0.0	0.0	0.300	0.0	0.0	1.
1080500	11	1	7	POTTING			1.	0.0	0.0	1.000	0.0	0.0	1.
1080600	11	1	7	CLAMPS			1.	0.0	0.0	1.000	0.0	0.0	1.
1080700	11	1	7	MAT			1.	0.0	0.0	5.500	0.0	0.0	1.
1080800	11	1	7	GRND STRAP			1.	0.0	0.0	1.500	0.0	0.0	1.
1090000	5	1	8	GFE DE-B			2.	150.92	0.0	0.0	0.0	0.0	1.
1090100	5	1	8	VEP			2.	0.0	9.90	0.0	0.0	0.0	1.
1090101	10	1	8	TUBULAR ANT			2.	0.0	0.0	1.786	0.0	0.0	6.
1090102	5	1	8	PREAMPS	229513A-2		2.	0.0	0.0	0.550	0.0	0.0	6.
1090103	5	1	8	ELECTRONICS	229513A-1		2.	0.0	0.0	6.600	0.0	0.0	1.
1090104	10	1	8	DISPENSER			2.	0.0	0.0	6.414	0.0	0.0	6.
1090200	5	1	8	MAG			2.	0.0	7.10	0.0	0.0	0.0	1.
1090201	10	1	8	SENSOR	2295124-2		2.	0.0	0.0	1.610	0.0	0.0	1.
1090202	10	1	8	ELECTRONICS	2295124-1		2.	0.0	0.0	6.538	0.0	0.0	1.
1090203	8	1	8	THRML BLNKT			2.	0.0	0.0	0.0	0.0	0.0	1.
1090300	5	1	8	IDM			2.	0.0	7.30	0.0	0.0	0.0	1.
1090301	8	1	8	ELECTRONICS	2295136-1		2.	0.0	0.0	4.070	0.0	0.0	1.
1090302	8	1	8	SENSOR	2295136-2		2.	0.0	0.0	3.430	0.0	0.0	1.
1090400	5	1	8	CAPT	2295135-1		2.	0.0	38.00	0.0	0.0	0.0	1.
1090401	5	1	8	DETECTORS			2.	0.0	0.0	9.300	0.0	0.0	1.
1090402	8	1	8	SCAN PLATE			2.	0.0	0.0	2.300	0.0	0.0	1.
1090403	8	1	8	TIP PLATE			2.	0.0	0.0	0.800	0.0	0.0	1.
1090405	8	1	8	MOVRE			2.	0.0	0.0	0.500	0.0	0.0	1.
1090407	8	1	8	CABLING			2.	0.0	0.0	1.500	0.0	0.0	1.

1090409	5	1	B	PPS		2.	0.0	0.0	2.000	0.0	0.0	2.
1090409	5	1	B	HVPS		2.	0.0	0.0	1.200	0.0	0.0	2.
1090410	5	1	B	EPD SYST		2.	0.0	0.0	0.500	0.0	0.0	1.
1090411	8	1	B	CEP		2.	0.0	0.0	6.000	0.0	0.0	1.
1090412	8	1	A	HV DISTR		2.	0.0	0.0	1.000	0.0	0.0	1.
1090413	8	1	B	THR BLNKT		2.	0.0	0.0	0.200	0.0	0.0	1.
1090414	10	1	A	MAG SCISOR		2.	0.0	0.0	0.750	0.0	0.0	1.
1090415	10	1	B	MAG DEPLOYER		2.	0.0	0.0	0.750	0.0	0.0	1.
1090500	5	1	B	MACS		2.	0.0	17.00	0.0	0.0	0.0	1.
1090501	12	1	B	ELECTRONICS	2295131-2	2.	0.0	0.0	6.000	0.0	0.0	1.
1090502	10	1	B	INSTRUMENT	2295131-1	2.	0.0	0.0	10.108	0.0	0.0	1.
1090503	10	1	B	COVER		2.	0.0	0.0	0.692	0.0	0.0	1.
1090600	5	1	A	EPI	2295135-1	2.	0.0	19.00	0.0	0.0	0.0	1.
1090601	5	1	A	ELECTRONICS		2.	0.0	0.0	5.000	0.0	0.0	1.
1090602	10	1	B	INSTRUMENT		2.	0.0	0.0	12.625	0.0	0.0	1.
1090603	5	1	B	CABLING		2.	0.0	0.0	0.288	0.0	0.0	1.
1090604	10	1	B	COVER		2.	0.0	0.0	0.375	0.0	0.0	1.
1090700	5	1	A	WATS		2.	0.0	17.00	0.0	0.0	0.0	1.
1090701	5	1	A	ELECTRONICS	2295132-1	2.	0.0	0.0	6.000	0.0	0.0	1.
1090702	10	1	A	SENSOR	2295132-3	2.	0.0	0.0	8.108	0.0	0.0	1.
1090703	10	1	A	COVER		2.	0.0	0.0	0.892	0.0	0.0	1.
1090800	5	1	B	LANS	2295137	2.	0.0	6.00	0.0	0.0	0.0	1.
1090801	5	1	A	SIG PROC		2.	0.0	0.0	3.900	0.0	0.0	1.
1090802	5	1	B	FILTER BOX		2.	0.0	0.0	0.500	0.0	0.0	2.
1090803	5	1	B	LATCH		2.	0.0	0.0	0.200	0.0	0.0	2.
1090804	5	1	B	PROBE		2.	0.0	0.0	0.250	0.0	0.0	2.
1090805	9	1	B	CABLING		2.	0.0	0.0	0.200	0.0	0.0	1.
1090900	5	1	A	RFA		2.	0.0	8.00	0.0	0.0	0.0	1.
1090901	5	1	B	ELECTRONICS	2295134-1	2.	0.0	0.0	4.800	0.0	0.0	1.
1090902	5	1	B	SENSOR	2295134	2.	0.0	0.0	3.800	0.0	0.0	1.
1100000	5	1	A	BALANCE -B-		3.	0.0	25.00	0.0	0.0	0.0	1.
1100100	10	1	A	S/C BALANCE		3.	0.0	0.0	28.810	0.0	0.0	1.
1100200	10	1	A	MAG BAL		3.	0.0	0.0	4.190	0.0	0.0	1.
1300000	5	1	A	SUPPT EQUIP		1.	0.0	0.0	0.0	0.0	0.0	1.
1300100	5	1	A	BOOMS		1.	22.50	22.50	0.0	0.0	0.0	1.
1300101	10	1	A	ASTROMAST		1.	0.0	0.0	2.323	0.0	0.0	1.
1300102	10	1	A	ASTRO HOUR		1.	0.0	0.0	11.677	0.0	0.0	1.
1300250	10	1	A	HARNESS MAG		1.	0.0	0.0	1.600	0.0	0.0	1.
1300300	10	1	A	SCAN PLATFRM		1.	0.0	28.10	0.0	0.0	0.0	1.
1300301	10	1	A	MTG PLATE		1.	0.0	0.0	9.400	0.0	0.0	1.
1300302	10	1	B	DRIVE		1.	0.0	0.0	9.400	0.0	0.0	1.
1300303	10	1	A	IFCE ELECTR		1.	0.0	0.0	3.500	0.0	0.0	1.
1300304	10	1	A	DRIVE ELECTR		1.	0.0	0.0	5.800	0.0	0.0	1.
1400000	5	1	B	EMC REVISION		1.	0.0	0.0	0.0	0.0	0.0	1.

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OF POOR QUALITY

DYNAMICS EXPLORER - DE-B
WEIGHT SUMMARY BY LEVELS
01 OCTOBER 1978

ID	NAME	PROPOSAL WEIGHT		CURRENT TARGET WEIGHT	CURRENT ESTIMATED ACT WT	QTY	DRWNG NO	SOURCE
1000000	DE-B	617.98	+	696.70	797.391	1.	2294700-501	
1010000	-STRUCTURE-B-	136.98	+	165.80	162.160	1.		
1010100	UPPER BP	0.0		0.0	23.480	1.		AE-C
1010200	LOWER BP	0.0		0.0	22.800	1.		
1010300	CEN COL/SH P	0.0	+	0.0	23.720	1.		
1010301	CENTER COL	0.0		0.0	9.200	1.		
1010302	SHR PANL 1	0.0		0.0	2.420	1.		
1010303	SHR PANL 2	0.0		0.0	2.420	1.		
1010304	SHR PANL 3	0.0		0.0	2.420	1.		
1010305	SHR PANL 4	0.0		0.0	2.420	1.		
1010306	SHR PANL 5	0.0		0.0	2.420	1.		
1010307	SHR PANL 6	0.0		0.0	2.420	1.		
1010500	SCP ATPT LWR	0.0		0.0	15.300	1.		
1010600	HAT UPPER	0.0	+	0.0	20.050	1.		
1010601	SIDES HU	0.0		0.0	15.700	1.		
1010602	END HU	0.0		0.0	4.350	1.		
1010700	HAT LOWER	0.0	+	0.0	20.050	1.		
1010701	SIDES HL	0.0		0.0	15.700	1.		
1010702	END HL	0.0		0.0	4.350	1.		
1010800	CENTER RING	0.0	+	0.0	16.000	1.		
1010801	RING	0.0		0.0	6.500	1.		
1010802	BRACKETS	0.0		0.0	9.500	1.		
1010900	HGA SUPPT CO	0.0		0.0	3.409	1.		
1011000	HARDWARE	0.0		0.0	1.000	1.		
1011100	BRKTS,MISC	0.0		0.0	2.500	1.		
1011200	COVERS+SEALS	0.0		0.0	4.200	1.		
1011300	LIFTING HDWR	0.0		0.0	1.200	1.		
1011400	RF SCREENS	0.0		0.0	1.200	4.		
1011500	HDWRE BOX	0.0		0.0	2.000	1.		
1011600	ANTENNA SUPT	0.0	+	0.0	4.000	1.		
1011601	DUL GN BIPD	0.0		0.0	1.500	1.		
1011602	HI GN BRGTNY	0.0		0.0	2.500	1.		
1011700	ATC BRACKETS	0.0		0.0	1.340	4.		
1020000	THERMAL -B-	10.40	+	10.50	10.480	1.		
1020100	THB-UPR HAT	0.0	+	0.0	6.150	1.		
1020101	THB-UPR HAT	0.0		0.0	3.750	1.		
1020102	ATC-UPR HAT	0.0		0.0	2.400	4.	2271611-503	
1020300	THB-UPR B/P	0.0	+	0.0	0.240	1.		
1020301	TEMP SENS-UB	0.0		0.0	0.240	1.		
1020400	THB-LWR B/P	0.0	+	0.0	3.990	1.		
1020401	TEMP SENS-LB	0.0		0.0	0.240	1.		
1020402	THB-LWR B/P	0.0		0.0	3.750	1.		
1020500	TH HEATERS	0.0		0.0	0.180	1.		
1030000	ATT CONTR B	99.70	+	100.10	92.600	1.		
1030200	PITCH CON EL	0.0		0.0	8.480	1.	2271623-501	
1030300	SUN SENSOR	0.0	+	0.0	3.800	1.		
1030301	DETECTORS	0.0		0.0	1.600	2.		
1030302	ELECTRONICS	0.0		0.0	2.200	2.		
1030400	NUT DPR+COIL	0.0	+	0.0	28.480	1.		

1030401	ROT DAMPER	0.0		0.0	16.400	1.			
1030402	ATT COIL	0.0		0.0	12.000	2.			
1030500	PITCH COIL	0.0		0.0	3.000	1.			
1030700	MOM WHL ASSY	0.0	◆	0.0	44.600	1.			
1030701	MOTOR ASSY	0.0		0.0	22.300	1.			
1030702	INERTIA WHL	0.0		0.0	22.300	1.			
1030800	WHL MOM SENS	0.0		0.0	2.000	1.			
1030900	MWA SHIELD	0.0		0.0	2.400	1.			
1040000	POWER	120.10	◆	127.10	130.910	1.			
1040100	UPPER SOL AR	0.0	◆	0.0	29.860	1.	2294644-502		
1040101	CELL MODULES	0.0		0.0	26.090	1.			
1040102	SHUNT WIRING	0.0		0.0	2.850	1.			
1040103	DIODES	0.0		0.0	0.920	1.			
1040200	LOWER SOL AR	0.0	◆	0.0	35.850	1.	2294744-502		
1040201	CELL MODULES	0.0		0.0	30.620	1.			
1040202	SHUNT WIRING	0.0		0.0	3.350	1.			
1040203	DIODES	0.0		0.0	1.880	1.			
1040300	BATTERIES	0.0	◆	0.0	43.400	1.			
1040301	BATT 1	0.0		0.0	21.700	1.	2294642-501		
1040302	BATT 2	0.0		0.0	21.700	1.	2294642-501		
1040400	PWR SUPL EL	0.0		0.0	22.600	1.	2294640-501		
1050000	CONNCTNS-B-	24.36	◆	33.20	33.200	1.			
1050100	TDRSS XPNDR	0.0		0.0	15.900	1.	2295161-1		
1050300	XPONDR CABLE	0.0		0.0	2.300	1.			
1050500	LOW GAIN ANT	0.0		0.0	1.400	1.			
1050600	HI. GAIN ANT	0.0		0.0	7.100	1.			
1050800	SW+FLT NTWRK	0.0		0.0	2.100	1.			
1050900	PREMOD PROC	0.0		0.0	4.400	1.			
1060000	C & DH	53.10	◆	62.30	62.300	1.			
1060100	CTP	0.0		0.0	9.100	1.	2294670-501		
1060200	CDU	0.0		0.0	10.800	1.	2294673-501		
1060300	PTM	0.0		0.0	8.400	1.	2294671-501		
1060400	TAPE RECORDR	0.0		0.0	34.000	2.		4.16.5-1	
1060000	S/C HARNESS	0.0	◆	0.0	64.700	1.	2295147-502		
1080100	UPPER HARN	0.0		0.0	27.500	1.	2294647-502		
1080200	LOWER HARN	0.0		0.0	27.500	1.	2294747-502		
1080300	GROUND BLOCK	0.0		0.0	0.400	1.			
1080400	GROUND BLOCK	0.0		0.0	0.300	1.			
1080500	POTTING	0.0		0.0	1.000	1.			
1080600	CLAMPS	0.0		0.0	1.000	1.			
1080700	MAT	0.0		0.0	5.500	1.			
1080800	GRND STRAP	0.0		0.0	1.500	1.			
1090000	GFC DE-B	150.32	◆	122.10	172.348	1.			
1090100	VCF	0.0	◆	9.90	59.180	1.			
1090101	TUBULAR ANT	0.0		0.0	10.716	6.			
1090102	PREAMPS	0.0		0.0	3.300	6.	2295138-2		
1090103	ELECTRONICS	0.0		0.0	6.600	1.	2295138-1		
1090104	DISPENSER	0.0		0.0	38.484	6.			
1090200	VAS	0.0	◆	7.10	8.148	1.			
1090201	SENSOR	0.0		0.0	1.610	1.	2295124-2		
1090202	ELECTRONICS	0.0		0.0	6.538	1.	2295124-1		
1090203	THRML BLNKT	0.0		0.0	0.0	1.			
1090300	IDM	0.0	◆	7.30	7.500	1.			
1090301	ELECTRONICS	0.0		0.0	4.070	1.	2295136-1		
1090302	SENSOR	0.0		0.0	3.430	1.	2295136-2		
1090400	LAPI	0.0	◆	30.00	38.000	1.	2295135-1		
1090401	DETECTORS	0.0		0.0	9.300	1.			
1090402	SCAN PLATE	0.0		0.0	2.300	1.			
1090403	TOP PLATE	0.0		0.0	0.800	1.			
1090406	MOYRE	0.0		0.0	0.500	1.			

1090407	CABLING	0.0		0.0	1.500	1.	
1090408	PPS	0.0		0.0	4.000	2.	
1090409	HVPS	0.0		0.0	2.400	2.	
1090410	EPD SYST	0.0		0.0	0.500	1.	
1090411	CEP	0.0		0.0	6.000	1.	
1090412	HV DISTR	0.0		0.0	1.000	1.	
1090413	THR BLNKT	0.0		0.0	0.200	1.	
1090414	MAG SENSOR	0.0		0.0	0.750	1.	
1090415	MAG DEPLOYER	0.0		0.0	0.750	1.	
1090500	MACS	0.0	◆	17.00	17.000	1.	
1090501	ELECTRONICS	0.0		0.0	6.000	1.	2295131-2
1090502	INSTRUMENT	0.0		0.0	10.108	1.	2295131-1
1090503	COVER	0.0		0.0	0.892	1.	
1090600	EPI	0.0	◆	19.00	19.000	1.	2295133-1
1090601	ELECTRONICS	0.0		0.0	5.600	1.	
1090602	INSTRUMENT	0.0		0.0	12.625	1.	
1090603	CABLING	0.0		0.0	0.200	1.	
1090604	COVER	0.0		0.0	0.375	1.	
1090700	MAYS	0.0	◆	17.00	17.000	1.	
1090701	ELECTRONICS	0.0		0.0	8.000	1.	2295132-1
1090702	SENSOR	0.0		0.0	8.108	1.	2295132-3
1090703	COVER	0.0		0.0	0.892	1.	
1090800	LANG	0.0	◆	6.00	6.000	1.	2295137
1090801	SIG PROC	0.0		0.0	3.900	1.	
1090802	FILTER BOX	0.0		0.0	1.000	2.	
1090803	LATCH	0.0		0.0	0.400	2.	
1090804	PROBE	0.0		0.0	0.500	2.	
1090805	CABLING	0.0		0.0	0.200	1.	
1090900	RPA	0.0	◆	8.80	8.600	1.	
1090901	ELECTRONICS	0.0		0.0	4.800	1.	2295134-1
1090902	SENSOR	0.0		0.0	3.800	1.	2295134
1100000	BALANCE -9-	0.0	◆	25.00	25.000	1.	
1100100	S/C BALANCE	0.0		0.0	20.810	1.	
1100200	MAG BAL	0.0		0.0	4.190	1.	
1300000	SUPPT EQUIP	22.50	◆	50.60	43.700	1.	
1300100	BOOMS	22.50	◆	22.50	14.000	1.	
1300101	ASTROMAST	0.0		0.0	2.325	1.	
1300102	ASTRO HDWR	0.0		0.0	11.677	1.	
1300200	HARNESS MAG	0.0		0.0	1.600	1.	
1300300	SCAN PLATFRM	0.0	◆	28.10	28.100	1.	
1300301	MTG PLATE	0.0		0.0	9.400	1.	
1300302	DRIVE	0.0		0.0	9.400	1.	
1300303	IFCE ELECTR	0.0		0.0	3.500	1.	
1300304	DRIVE ELECTR	0.0		0.0	5.800	1.	
1400000	EMC REVISION	0.0		0.0	0.0	1.	

DYANICS EXPLORER BE-B
ZONE AND PHASE SUMMARY
01 OCTOBER 1978

ZONE	PROPOSAL WEIGHT	CURRENT TARGET WEIGHT	CURRENT ESTIMATED WEIGHT
1	467.06	549.60	600.046
2	150.92	122.10	172.348
3	0.0	25.00	25.000

PHASE	PROPOSAL WT	CURRENT TARGET WT	CURRENT EST/ACT WT
TOTAL SYSTEM LAUNCH WEIGHT INCL BAL WT	617.98	696.70	797.394
SPACECRAFT HARDWARE WEIGHT INCL BAL	467.06	549.60	600.046
GFE INSTRUMENTATION WEIGHT	150.92	122.10	172.348
TOTAL BALANCE WEIGHT	0.0	25.00	25.000

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DYANICS EXPLORER DE-B
INPUT MOMENT OF INERTIA AND C.G. INFORMATION
01 OCTOBER 1978

NOMENCLATURE	ID.NO.	TP	NO	PA	LX/IXX	LY/IYY	LZ/IZZ	RAD.O	RAD.I	XBAR	YBAR	ZBAR	WEIGHT
UPPER BP	1010100	13	1	0	4145.9	4145.9	8291.0	0.0	0.0	0.0	0.0	-8.5	23.40
LOWER BP	1010200	13	1	0	4145.9	4145.9	8291.0	0.0	0.0	0.0	0.0	8.5	22.80
CENTER CYL	1010301	13	1	0	480.3	480.3	354.3	0.0	0.0	0.0	0.0	0.0	9.20
SHR PANL 1	1010302	1	1	1	17.9	0.1	16.8	0.0	0.0	-15.2	0.0	0.0	2.42
SHR PANL 2	1010303	1	1	0	18.9	0.1	16.8	0.0	0.0	-7.6	13.6	0.0	2.42
SHR PANL 3	1010304	1	1	1	18.9	0.1	16.8	0.0	0.0	7.6	13.6	0.0	2.42
SHR PANL 4	1010305	1	1	1	17.9	0.1	16.8	0.0	0.0	15.2	0.0	0.0	2.42
SHR PANL 5	1010306	1	1	1	18.9	0.1	16.8	0.0	0.0	7.6	-13.6	0.0	2.42
SHR PANL 6	1010307	1	1	1	18.9	0.1	16.8	0.0	0.0	-7.6	-13.6	0.0	2.42
SEP ATPT LWR	1010500	13	1	0	1346.2	1346.2	589.3	0.0	0.0	0.0	0.0	16.6	15.30
SIDES MU	1010691	9	1	0	0.0	0.0	20.9	26.6	26.2	0.0	0.0	-12.5	15.70
END MU	1010692	9	1	0	0.0	0.0	0.5	26.2	9.0	0.0	0.0	-22.5	4.35
SIDES ML	1010701	9	1	0	0.0	0.0	20.9	26.6	26.2	0.0	0.0	12.5	15.70
END ML	1010702	9	1	0	0.0	0.0	0.5	26.2	9.0	0.0	0.0	22.5	4.35
CENTER RING	1010800	9	1	0	0.0	0.0	3.0	26.5	26.4	0.0	0.0	0.0	16.00
MOA SUPPT CO	1010900	13	1	0	59.1	59.1	73.6	0.0	0.0	0.0	0.0	-13.1	3.40
BRKTS,MISC	1011100	9	1	0	0.0	0.0	4.0	25.0	9.0	0.0	0.0	0.0	2.50
COVERS+SEALS	1011200	9	1	0	0.0	0.0	17.5	25.0	9.0	0.0	0.0	0.0	4.20
LIFTING HDWR	1011300	12	1	0	0.0	0.0	4.0	25.0	0.0	0.0	0.0	0.0	1.20
RF SCREENS	1011400	4	1	0	0.0	0.0	0.1	10.3	0.0	11.0	11.0	-22.5	0.30
RF SCREENS	1011400	4	1	0	0.0	0.0	0.1	10.3	0.0	-11.0	11.0	-22.5	0.30
RF SCREENS	1011400	4	1	0	0.0	0.0	0.1	10.3	0.0	-11.0	-11.0	-22.5	0.30
RF SCREENS	1011400	4	1	0	0.0	0.0	0.1	10.3	0.0	11.0	-11.0	-22.5	0.30
HDWRE 60/	1011500	9	0	0	0.0	0.0	20.0	25.0	9.0	0.0	0.0	0.0	2.60
DUL GN BIPD	1011601	13	1	0	378.1	378.1	264.7	0.0	0.0	0.0	0.0	-49.5	1.50
MI GN BRGTRY	1011602	1	1	0	3.0	1.0	6.0	0.0	0.0	0.0	-23.5	-25.5	2.50
ATC BRACKETS	1011700	4	1	0	0.0	0.0	0.7	1.5	0.0	11.0	11.0	-21.5	0.33
ATC BRACKETS	1011700	4	1	0	0.0	0.0	0.7	1.5	0.0	-11.0	11.0	-21.5	0.33
ATC BRACKETS	1011700	4	1	0	0.0	0.0	0.7	1.5	0.0	-11.0	-11.0	-21.5	0.33
ATC BRACKETS	1011700	4	1	0	0.0	0.0	0.7	1.5	0.0	11.0	-11.0	-21.5	0.33
THB-UPR HAT	1020101	9	1	0	0.0	0.0	20.9	25.0	24.9	0.0	0.0	-10.4	3.75
ATC-UPR HAT	1020102	4	1	0	0.0	0.0	0.7	10.3	0.0	11.0	11.0	-22.0	0.60
ATC-UPR HAT	1020102	4	1	0	0.0	0.0	0.7	10.3	0.0	-11.0	11.0	-22.0	0.60
ATC-UPR HAT	1020102	4	1	0	0.0	0.0	0.7	10.3	0.0	-11.0	-11.0	-22.0	0.60
ATC-UPR HAT	1020102	4	1	0	0.0	0.0	0.7	10.3	0.0	11.0	-11.0	-22.0	0.60
TEMP SENS-UB	1020301	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-8.0	0.24
TEMP SENS-LB	1020401	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.24
THB-LWR B/P	1020402	13	1	0	960.9	960.9	1589.1	0.0	0.0	0.0	0.0	17.5	3.75
TH HEATERS	1020500	1	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10
PITCH CON EL	1030200	1	1	1	8.3	5.9	7.9	0.0	0.0	7.4	19.1	-3.9	0.40
DETECTORS	1030301	1	1	0	2.0	2.0	2.0	0.0	0.0	24.0	12.0	21.0	0.80
DETECTORS	1030301	1	1	0	2.0	2.0	2.0	0.0	0.0	24.0	12.0	-21.0	0.80
ELECTRONICS	1030302	1	1	0	2.0	2.0	2.0	0.0	0.0	18.5	11.5	-9.0	1.10
ELECTRONICS	1030302	1	1	0	2.0	2.0	2.0	0.0	0.0	18.5	11.5	9.0	1.10
NUT DAMPER	1030401	13	1	0	6732.7	3518.2	3872.9	0.0	0.0	-14.0	0.0	0.0	16.00
ATT COIL	1030402	13	1	0	1950.7	1950.7	3901.5	0.0	0.0	0.0	0.0	7.5	6.00
PITCH COIL	1030500	13	1	0	1231.6	722.9	722.9	0.0	0.0	-14.0	0.0	0.0	3.00
MOTOR ASSY	1030701	4	1	0	0.0	0.0	12.0	3.3	0.0	0.0	0.0	-16.5	22.30
INERTIA WHL	1030702	13	1	0	1227.8	1227.8	2441.6	0.0	0.0	0.0	0.0	-20.0	22.30
WHL MOM SENS	1030800	4	1	0	0.0	0.0	12.0	3.3	0.0	0.0	0.0	-16.5	2.80
MOA SHIELD	1030900	4	1	0	0.0	0.0	12.0	3.3	0.0	0.0	0.0	-16.5	2.60
UPPER SOL AR	1040100	9	1	0	0.0	0.0	21.0	26.4	26.3	0.0	0.0	-12.0	29.86
LOWER SOL AR	1040200	13	1	0	13067.9	13067.9	20916.5	0.0	0.0	0.0	0.0	14.0	35.05

BATT 1	1040301	1	1	0	5.4	11.3	4.8	0.0	0.0	-2.0	16.0	-5.4	21.70
BATT 2	1040302	1	1	0	11.3	5.4	4.8	0.0	0.0	-17.0	4.5	-5.4	21.70
PWR SUPL EL	1040403	1	1	0	14.6	7.5	8.8	0.0	0.0	0.0	-20.0	-3.4	22.40
TDRSS XPONDR	1050100	1	1	0	6.3	13.9	4.3	0.0	0.0	3.9	-17.5	-10.5	15.90
XPONDR CABLE	1050300	1	1	0	6.3	13.9	4.3	0.0	0.0	3.9	-17.5	-10.5	2.30
LOW GAIN ANT	1050500	4	1	0	0.0	0.0	3.0	1.3	0.0	0.0	0.0	-57.0	1.40
HI GAIN ANT	1050600	1	1	0	28.0	7.0	2.0	0.0	0.0	0.0	-26.0	-25.5	7.10
SWITCH NETWRK	1050800	1	1	0	6.3	13.9	4.3	0.0	0.0	0.0	-14.5	-10.5	2.10
PKEMOD PROC	1050900	1	1	0	6.3	4.0	3.0	0.0	0.0	-0.3	20.9	-10.6	4.40
CTP	1060100	1	1	0	6.0	12.5	6.0	0.0	0.0	-11.5	2.9	-13.1	9.10
CDU	1060200	1	1	0	6.9	9.2	8.8	0.0	0.0	10.5	16.0	13.1	10.80
RTU	1060300	1	1	0	9.2	6.9	8.8	0.0	0.0	-3.5	10.5	13.1	6.40
TAPE RECORDR	1060400	1	1	0	9.0	13.0	6.0	0.0	0.0	12.5	0.0	11.8	17.00
TAPE RECORDR	1060400	1	1	0	9.0	13.0	6.0	0.0	0.0	-12.5	0.0	11.8	17.00
UPPER HARN	1060100	12	1	0	0.0	0.0	4.0	25.0	9.0	0.0	0.0	-10.6	27.50
LOWER HARN	1060200	12	1	0	0.0	0.0	4.0	25.0	9.0	0.0	0.0	10.8	27.50
GROUND BLOCK	1060300	9	1	0	0.0	0.0	4.0	25.0	9.0	0.0	0.0	-10.6	0.40
GROUND BLOCK	1060400	9	1	0	0.0	0.0	4.0	25.0	9.0	0.0	0.0	10.6	0.30
POTTING	1060500	9	1	0	0.0	0.0	4.0	25.0	9.0	0.0	0.0	-10.6	1.60
CLAMPS	1060600	9	1	0	0.0	0.0	4.0	25.0	9.0	0.0	0.0	10.8	1.00
MAT	1060700	9	1	0	0.0	0.0	4.0	25.0	9.0	0.0	0.0	10.6	5.50
GRND STRAP	1060800	9	1	0	0.0	0.0	4.0	25.0	9.0	0.0	0.0	-10.6	1.50
PREAMPS	1090102	1	1	0	3.8	2.5	1.3	0.0	0.0	-21.7	-5.2	9.4	0.55
PREAMPS	1090102	1	1	0	3.8	2.5	1.3	0.0	0.0	-21.7	0.0	-9.4	0.55
PREAMPS	1090102	1	1	1	3.8	2.5	1.3	0.0	0.0	10.5	11.5	7.1	0.55
PREAMPS	1090102	1	1	1	2.5	3.8	1.3	0.0	0.0	13.5	-10.8	-7.1	0.55
PREAMPS	1090102	1	1	1	3.8	2.5	1.3	0.0	0.0	-10.5	-11.5	7.1	0.55
PREAMPS	1090102	1	1	1	2.5	3.8	1.3	0.0	0.0	-10.5	11.5	-7.1	0.55
ELECTRONICS	1090103	1	1	0	8.9	9.4	7.5	0.0	0.0	2.0	-10.5	12.5	6.60
DISPENSER	1090104	13	1	0	193.8	167.3	47.9	0.0	0.0	-21.0	0.0	-15.4	6.41
DISPENSER	1090104	13	1	0	193.8	167.3	47.9	0.0	0.0	-21.0	0.0	15.4	6.41
DISPENSER	1090104	13	1	1	76.7	196.5	148.9	0.0	0.0	11.0	-11.0	0.0	6.41
DISPENSER	1090104	13	1	1	76.7	196.5	148.9	0.0	0.0	-11.0	-11.0	0.0	6.41
DISPENSER	1090104	13	1	1	76.7	196.5	148.9	0.0	0.0	-11.0	11.0	0.0	6.41
DISPENSER	1090104	13	1	1	76.7	196.5	148.9	0.0	0.0	11.0	11.0	0.0	6.41
SENSOR	1090201	1	1	0	3.0	6.7	6.7	0.0	0.0	-20.0	-6.2	0.0	1.61
ELECTRONICS	1090202	1	1	0	7.0	8.5	6.1	0.0	0.0	-7.5	-12.0	11.8	6.54
THRML BLNKT	1090203	1	1	0	7.0	8.5	6.1	0.0	0.0	-7.5	-12.0	11.8	0.0
ELECTRONICS	1090301	1	1	0	7.3	5.0	6.3	0.0	0.0	10.0	9.0	11.8	9.87
SENSOR	1090302	1	1	0	3.0	5.0	9.7	0.0	0.0	24.0	3.4	13.5	3.43
DETECTORS	1090401	4	1	0	0.0	0.0	6.5	5.0	0.0	0.0	0.0	28.0	9.30
SCAN PLATE	1090402	4	1	0	0.0	0.0	0.4	7.0	0.0	3.0	0.0	25.4	2.30
TOP PLATE	1090403	4	1	0	0.0	0.0	0.3	7.0	0.0	0.0	0.0	32.2	0.80
HOUSE	1090405	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	0.50
CABLING	1090407	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	1.50
PPS	1090408	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	2.00
PPS	1090408	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	2.00
HVPS	1090409	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	1.20
HVPS	1090409	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	1.20
EPD SYST	1090410	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	0.50
CEP	1090411	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	6.00
HV DISTR	1090412	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	1.00
THR BLNKT	1090413	4	1	0	0.0	0.0	6.5	6.5	0.0	0.0	0.0	28.1	0.20
MAG SENSOR	1090414	4	1	0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	33.9	0.75
MAG DEPLOYER	1090415	12	1	0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	33.9	0.75
ELECTRONICS	1090501	1	1	0	7.0	7.0	7.0	0.0	0.0	28.1	4.2	-4.2	6.00
INSTRUMENT	1090502	1	1	0	11.5	6.5	6.0	0.0	0.0	10.0	-3.6	-3.6	10.11
ELECTRONICS	1090601	1	1	0	7.0	5.0	6.0	0.0	0.0	0.0	22.6	-11.8	9.60
INSTRUMENT	1090602	13	1	1	405.3	550.0	932.9	0.0	0.0	10.5	12.7	-10.3	12.63
CABLING	1090603	1	1	0	7.0	5.0	6.0	0.0	0.0	0.0	22.6	-11.8	0.20

ELECTRONICS	1998701	1	1	0	7.0	77.8	7.0	0.0	0.0	11.2	13.4	-18.2	0.00			
SENSOR	1999702	1	1	0	18.5	7.0	8.0	0.0	0.0	19.9	-2.6	-13.0	8.11			
SIG PROC	1998801	1	1	0	16.0	5.5	4.7	0.0	0.0	11.5	-17.5	11.1	3.99			
FILTER BOX	1998802	1	1	0	4.3	2.0	3.5	0.0	0.0	1.0	26.1	10.3	0.56			
FILTER BOX	1998802	1	1	0	4.3	2.0	3.5	0.0	0.0	1.0	-26.1	10.3	0.30			
LATCH	1998803	1	1	0	4.3	2.0	3.5	0.0	0.0	1.0	26.1	10.3	0.30			
LATCH	1998803	1	1	0	4.3	2.0	3.5	0.0	0.0	1.0	-26.1	10.3	0.20			
PROBE	1998804	4	1	0	0.0	0.0	29.5	0.1	0.0	0.0	26.1	0.0	0.00			
PROBE	1998804	4	1	0	0.0	0.0	29.5	0.1	0.0	0.0	-26.1	0.0	0.00			
CABLING	1998805	1	1	0	6.0	5.5	4.7	0.0	0.0	-7.7	19.9	11.1	0.20			
ELECTRONICS	1998901	1	1	0	9.1	5.0	6.3	0.0	0.0	16.5	-18.0	11.9	4.66			
SENSOR	1998902	0	1	0	3.0	5.0	9.7	0.0	0.0	24.0	-3.4	13.5	3.00			
MAG BAL	1168200	2	1	0	8.5	6.0	8.0	5.0	0.0	-26.5	-6.2	8.3	4.10			
ASTRONAST	1300101	2	1	0	15.0	0.0	0.0	5.0	0.0	-18.0	-6.6	0.0	2.32			
ASTRO MOUR	1300102	2	1	0	15.0	0.0	0.0	5.0	0.0	-18.0	-6.6	0.0	11.60			
HARNESS TAG	1300200	2	1	0	15.0	0.0	0.0	5.0	0.0	-18.0	-6.6	0.0	1.40			
MTG PLATE	1300301	9	1	0	0.0	0.0	0.1	6.0	2.2	0.0	0.0	12.4	9.00			
DRIVE	1300302	4	1	0	0.0	0.0	12.6	1.5	0.0	0.0	0.0	6.4	9.00			
IFCE ELECTR	1300303	1	1	0	7.4	5.4	5.0	0.0	0.0	-13.0	10.3	11.3	3.50			
DRIVE ELECTR	1300304	1	1	0	7.4	5.4	5.0	0.0	0.0	-13.0	10.3	11.3	5.00			

DYANICS EXPLORER DE-B
MOMENT OF INERTIA CALCULATIONS
80% INERTIA VALUES

NAME	IXX	IYY	IZZ	TYPE
UPPER BP	4145.879	4145.879	8291.880	13
LOWER BP	4145.879	4145.879	8291.880	13
CENTER CYL	680.340	680.340	354.320	13
SHR PANL 1	56.921	121.246	64.330	1
SHR PANL 2	56.920	129.932	72.116	1
SHR PANL 3	56.920	129.932	72.116	1
SHR PANL 4	56.921	121.534	64.619	1
SHR PANL 5	56.920	129.932	72.116	1
SHR PANL 6	56.920	129.932	72.116	1
SEP ATPT LWR	1346.248	1346.248	589.388	13
SIDES HU	6938.762	6938.762	10934.547	9
END HU	534.688	534.688	1669.181	9
SIDES HL	6038.762	6038.762	10934.547	9
END HL	534.688	334.688	1669.181	9
CENTER RING	5619.486	5619.486	11214.816	9
MWA SUPPT CO	59.124	59.124	75.618	13
BRKTS.MISC	444.583	444.583	882.500	9
COVERS+SEALS	848.487	848.487	1482.688	9
LIFTING HDWR.	376.600	376.600	750.000	12
RF SCREENS	8.883	8.883	16.886	4
RF SCREENS	8.883	8.883	16.886	4
RF SCREENS	8.883	8.883	16.886	4
RF SCREENS	8.883	8.883	16.886	4
HDWRE MISC	419.667	419.667	786.000	9
DUAL GN DIPU	378.158	378.158	264.640	13
HI GN ANTRY	7.788	9.375	2.883	1
ATC BRACKETS	0.282	0.282	0.377	4
ATC BRACKETS	0.282	0.282	0.377	4
ATC BRACKETS	0.282	0.282	0.377	4
ATC BRACKETS	0.282	0.282	0.377	4
TNB-UPR HAT	1302.532	1302.532	2332.861	9
ATC-UPR HAT	15.938	15.938	31.827	4
ATC-UPR HAT	15.938	15.938	31.827	4
ATC-UPR HAT	15.938	15.938	31.827	4
ATC-UPR HAT	15.938	15.938	31.827	4
TEMP SENS-UB	0.0	0.0	0.0	1
TEMP SENS-LB	0.0	0.0	0.0	1
TNB-LWR B/P	960.860	960.860	1509.188	13
TN HEATERS	0.0	0.0	0.0	1
PITCH CON EL	68.054	91.910	72.590	1
DETECTORS	0.533	0.533	0.533	1
DETECTORS	0.533	0.533	0.533	1
ELECTRONICS	0.733	0.733	0.733	1
ELECTRONICS	0.733	0.733	0.733	1
NUT DAMPER	6732.695	3518.208	3872.888	13
ATT COIL	1950.750	1950.750	3901.500	13
PITCH COIL	1231.600	722.900	722.900	13
ROTOR ASSY	328.312	328.312	121.424	4
INERTIA WHL	1227.778	1227.778	2441.628	13
WHL MOM SENS	29.445	29.445	10.890	4
M.A SHIELD	35.334	35.334	13.066	4
UPPER SOL AR	11[illegible]5.109	11495.139	28795.516	9
LOWER SOL AR	13967.898	13967.898	28916.500	13

BATT 1	272.578	94.395	283.637	1
BATT 2	94.395	272.578	283.637	1
PWR SUPL EL	251.783	547.296	587.389	1
TORUS RCVDR	298.845	76.688	387.761	1
RPONDR CABLE	48.625	11.891	44.519	1
LOW GAIN ANT	1.597	1.597	1.094	4
HIGH GAIN ANT	31.358	466.235	492.458	1
S/C FLT SFTWRK	37.239	16.117	48.794	1
PREPROD PROC	11.823	19.789	26.428	1
CTP	173.454	93.791	149.794	1
CGU	145.872	112.545	119.825	1
RTM	87.535	113.456	92.575	1
TAPE RECORDR	298.417	165.758	354.167	1
TAPE RECORDR	298.417	165.758	354.167	1
UPPER HARN	8638.414	8638.414	17187.568	12
LOWER HARN	8638.414	8638.414	17187.568	12
GROUND BLOCK	71.133	71.133	141.288	9
GROUND BLOCK	53.358	53.358	105.968	9
POTTING	177.933	177.933	353.088	9
CLAMPS	177.933	177.933	353.088	9
MAT	978.943	978.883	1941.588	9
GRND STRAP	266.758	266.758	529.588	9
PREAMPS	0.364	0.722	0.931	1
PREAMPS	0.364	0.722	0.931	1
PREAMPS	0.364	0.722	0.931	1
PREAMPS	0.722	0.364	0.931	1
PREAMPS	0.364	0.722	0.931	1
PREAMPS	0.722	0.364	0.931	1
ELECTRONICS	79.535	66.137	83.798	1
DISPENSER	193.838	167.388	47.968	13
DISPENSER	193.838	167.388	47.988	13
DISPENSER	76.788	196.588	148.988	13
DISPENSER	76.788	196.588	148.988	13
DISPENSER	76.788	196.588	148.988	13
DISPENSER	76.788	196.588	148.988	13
SENSOR	12.845	7.238	7.238	1
ELECTRONICS	59.637	46.378	66.861	1
THRML BLNKT	0.0	0.0	0.0	1
ELECTRONICS	21.728	31.521	26.752	1
SENSOR	34.348	29.467	9.718	1
DETECTORS	118.957	118.957	156.426	4
SCAN PLATE	28.286	28.286	96.358	4
TOP PLATE	9.896	9.896	19.688	4
HOUSE	7.863	7.763	10.563	4
CABLING	21.198	21.198	31.688	4
PPS	28.254	28.254	42.258	4
PPS	28.254	28.254	42.258	4
HVPS	16.952	16.952	25.358	4
HVPS	16.952	16.952	25.358	4
EPD SYST	7.863	7.963	10.563	4
CEP	84.761	84.761	126.758	4
HV DISTR	14.127	14.127	21.125	4
THR BLNKT	2.825	2.825	4.225	4
RAD SENSOR	1.888	1.888	1.586	4
RAD DEPLOYER	9.211	9.211	8.422	12
ELECTRONICS	49.888	84.531	94.531	1
INSTRUMENT	65.913	141.723	146.987	1
ELECTRONICS	29.483	41.863	35.767	1
INSTRUMENT	485.348	358.888	932.898	13
CABLING	1.817	1.417	1.233	1

ELECTRONICS	72.788	65.333	72.788	1
SENSOR	57.432	73.141	81.928	1
SIG PROC	17.8.8	14.879	21.531	1
FILTER BOX	0.677	1.263	0.919	1
FILTER BOX	0.677	1.263	0.919	1
LATCH	0.271	0.505	0.368	1
LATCH	0.271	0.505	0.368	1
PROBE	18.131	18.131	0.001	4
PROBE	18.131	18.131	0.001	4
CABLING	0.872	0.968	1.184	1
ELECTRONICS	25.625	49.041	43.416	1
SENSOR	37.872	32.805	10.767	0
MAG BAL	32.375	26.275	26.275	2
ASTROMAST	29.637	58.075	58.075	2
ASTRO BOOM	145.962	291.925	291.925	2
HARNESS MAG	20.000	40.000	40.000	2
MTG PLATE	95.982	99.982	191.948	9
DRIVE	118.087	118.087	10.575	4
IFCE ELECTR	15.797	23.265	24.477	1
DRIVE ELECTR	26.177	38.551	40.561	1

DYANICS EXPLORER DE-B
MOMENT OF INERTIA CALCULATIONS
BOX AXIS ROTATION FOR NONPARALLEL AXES

NAME	IXX	IYY	IZZ	IXY	IXZ	IYZ	ANG1	ANG2	ANG3	ANG4
UPPER RP	4145.879	4145.879	8291.000							
LOWER RP	4145.879	4145.879	8291.000							
CENTER CBE	480.340	480.340	354.320							
SHR PANL 1	56.921	121.246	64.330	0.000	-0.000	0.000	180.0	270.0	90.0	90.0
SHR PANL 2	56.920	129.032	72.116							
SHR PANL 3	111.084	74.948	72.116	31.225	0.000	-0.000	60.0	150.0	90.0	90.0
SHR PANL 4	56.921	121.534	64.619	-0.000	0.000	-0.000	0.0	90.0	90.0	90.0
SHR PANL 5	46.486	139.464	54.087	-31.225	0.000	-0.000	300.0	60.0	90.0	90.0
SHR PANL 6	111.084	74.948	72.116	31.225	-0.000	0.000	240.0	330.0	90.0	90.0
SEP ATET LWR	1346.240	1346.240	589.300							
SIDES MU	6038.762	6038.762	10934.547							
END MU	834.688	834.688	1669.181							
SIDES ML	6038.762	6038.762	10934.547							
END ML	834.688	834.688	1669.181							
CENTER RING	5619.406	5619.406	11214.816							
MAA SUPPT CO	59.124	59.124	73.610							
BRKTS,MISC	444.583	444.583	882.500							
COVERS+SEALS	548.487	548.487	1482.660							
LIFTING EDWR	376.600	376.600	750.000							
RF SCREENS	8.003	8.003	16.006							
RF SCREENS	8.003	8.003	16.006							
RF SCREENS	8.003	8.003	16.006							
RF SCREENS	8.003	8.003	16.006							
EDWRE BOX	419.667	419.667	706.000							
DUL GN RIPD	378.150	378.150	264.680							
MI GN ERSTRY	7.708	9.375	2.083							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
ATC BRACKETS	0.202	0.202	0.377							
THB-UPR HAT	1302.552	1302.552	2332.061							
ATC-UPR HAT	15.938	15.938	31.827							
ATC-UPR HAT	15.938	15.938	31.827							
ATC-UPR HAT	15.938	15.938	31.827							
ATC-UPR HAT	15.938	15.938	31.827							
TEMP SENS-UB	0.0	0.0	0.0							
TEMP SENS-LB	0.0	0.0	0.0							
THB-LWR S/P	960.860	960.860	1589.100							
TH HEATERS	0.0	0.0	0.0							
PITCH CON EL	84.062	75.902	72.590	11.289	0.000	-0.000	55.0	145.0	90.0	90.0
DETECTORS	0.533	0.533	0.533							
DETECTORS	0.533	0.533	0.533							
ELECTRONICS	0.733	0.733	0.733							
ELECTRONICS	0.733	0.733	0.733							
NUT DAMPER	6732.699	3518.200	3872.680							
ATT COIL	1950.750	1950.750	3901.500							
PITCH COIL	1231.600	722.900	722.900							
MOTOR ASSY	325.312	325.312	121.424							
INERTIA WHL	1227.770	1227.770	2441.620							
WHL MOR SENS	29.445	29.445	10.890							
MAA SHIELD	35.334	35.334	13.068							
UPPER SOL AR	11495.109	11495.109	20795.516							
LOWER SOL AR	13067.898	13067.898	20916.500							

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BATT 1	272.570	90.395	283.637													
BATT 2	90.395	272.570	283.637													
PWR SUPL EL	251.793	347.296	507.389													
TGRSS XCVDR	283.845	76.060	307.761													
XPONDR CABLE	40.625	11.081	44.519													
LOW GAIN ANT	1.597	1.597	1.094													
HIGH GAIN ANT	31.358	466.235	492.658													
SW+FLT TWTA	37.259	10.117	40.794													
PREMOD PROC	11.023	19.709	20.420													
CTP	173.454	93.791	149.794													
CDU	145.972	112.545	119.025													
RTM	87.535	113.456	92.575													
TAPE RECORDR	290.417	165.750	354.167													
TAPE RECORDR	290.417	165.750	354.167													
UPPER HARN	8630.414	8630.414	17187.500													
LOWER HARN	8630.414	8630.414	17187.500													
GROUND BLOCK	71.133	71.133	141.200													
GROUND BLOCK	53.350	53.350	105.900													
FOTTING	177.833	177.833	353.000													
CLAMPS	177.833	177.833	353.000													
MAT	978.083	978.083	1941.500													
GRND STRAP	266.750	266.750	529.500													
PREAMPS	0.364	0.722	0.931													
PREAMPS	0.364	0.722	0.931													
PREAMPS	0.543	0.543	0.931	0.179	0.000	0.000	45.0	135.0	90.0	90.0						
PREAMPS	0.543	0.543	0.931	-0.179	-0.000	0.000	45.0	135.0	90.0	90.0						
PREAMPS	0.543	0.543	0.931	0.179	0.000	0.000	45.0	135.0	90.0	90.0						
PREAMPS	0.543	0.543	0.931	-0.179	-0.000	0.000	45.0	135.0	90.0	90.0						
ELECTRONICS	79.035	66.137	83.798													
DISPENSER	193.800	167.300	47.900													
DISPENSER	193.800	167.300	47.900													
DISPENSER	136.600	136.600	140.900	-59.900	-0.000	0.000	135.0	225.0	90.0	90.0						
DISPENSER	136.600	136.600	140.900	59.900	0.000	0.000	45.0	135.0	90.0	90.0						
DISPENSER	136.600	136.600	140.900	-59.900	-0.000	0.000	135.0	225.0	90.0	90.0						
DISPENSER	136.600	136.600	140.900	59.900	0.000	0.000	45.0	135.0	90.0	90.0						
SENSOR	12.245	7.230	7.230													
ELECTRONICS	59.537	46.979	66.061													
THRML BLNKT	0.0	0.0	0.0													
ELECTRONICS	21.728	31.521	26.752													
SENSOR	34.040	29.467	9.718													
DETECTORS	110.957	110.957	156.426													
SCAN PLATE	28.206	28.206	56.350													
TOP PLATE	9.806	9.806	19.600													
HOUSE	7.063	7.063	10.563													
CABLING	21.190	21.190	31.688													
PPS	28.254	28.254	42.250													
PPS	28.254	28.254	42.250													
HVPS	16.952	16.952	25.350													
HVPS	16.952	16.952	25.350													
EPD SYST	7.063	7.063	10.563													
CEP	84.761	84.761	126.750													
HV DISTR	14.127	14.127	21.125													
THR BLNKT	2.825	2.825	4.225													
MAG SENSOR	1.000	1.000	1.500													
MAG DEPLOYER	9.211	9.211	0.422													
ELECTRONICS	49.000	54.531	54.531													
INSTRUMENT	65.913	141.723	146.987													
ELECTRONICS	29.483	41.383	55.767													
INSTRUMENT	545.637	409.702	932.890	24.738	-0.000	0.000	88.3	178.8	90.0	90.0						
CABLING	1.017	1.417	1.233													

ELECTRONICS	72.708	65.333	72.708
SENSOR	57.432	73.141	81.925
SIG PROC	17.310	18.873	21.531
FILTER BOX	0.677	1.263	0.919
FILTER BOX	0.677	1.263	0.919
LATCH	0.271	0.505	0.368
LATCH	0.271	0.505	0.368
PROBE	18.131	18.131	0.001
PROBE	18.131	18.131	0.001
CABLING	0.672	0.968	1.104
ELECTRONICS	25.625	49.041	43.416
SENSOR	37.872	32.805	10.767
MAG BAL	52.375	26.275	26.275
ASTROMAST	29.037	58.075	58.075
ASTRO BOOM	145.962	291.925	291.925
HARNESS MAG	20.006	40.000	40.000
MTG PLATE	95.982	95.982	191.948
DRIVE	118.087	118.087	10.575
IFCE ELECTR	15.797	23.263	24.477
DRIVE ELECTR	26.177	38.551	40.561

DYNAMICS EXPLORER DE-B
MOMENT OF INERTIA CALCULATIONS ABOUT S/CAXIS

AN ASTERISK INDICATES THE TOTAL SUM OF THE MOMENTS OF BOX COMPONENTS

ID	NAME	IXX	IYY	IZZ
1010100	UPPER BP	5828.5781	5828.5781	8291.0000
1010200	LOWER BP	5785.4336	5785.4336	8291.0000
1010301	CENTER COL	480.3401	480.3401	354.3201
1010302	SHR PANL 1	56.9212	680.3625	623.4470
1010303	SHR PANL 2	501.2360	277.3994	664.6010
1010304	SHR PANL 3	555.3218	223.3158	664.6010
1010305	SHR PANL 4	56.9212	680.6509	623.7354
1010306	SHR PANL 5	490.8059	287.8315	646.7720
1010307	SHR PANL 6	555.3218	223.3158	664.6010
1010500	SEP ATPT LWR	5557.2227	5557.2227	5809.3000
1010601	SIDES MU	8491.8828	8491.8828	10934.5469
1010602	END MU	3036.8760	3036.8760	1669.1814
1010701	SIDES ML	8491.8828	8491.8828	10934.5469
1010702	END ML	3036.8760	3036.8760	1669.1814
1010800	CENTER RING	5619.4062	5619.4062	11214.8164
1010900	MWA SUPPT CO	647.0681	647.0681	73.6100
1011100	BRKTS,MISC	444.5833	444.5833	882.5000
1011200	COVERS+SEALS	848.4873	848.4873	1482.5999
1011300	LIFTING HDWR	376.5996	376.5996	749.9995
1011400	RF SCREENS	196.1784	196.1784	88.6063
1011400	RF SCREENS	196.1784	196.1784	88.6063
1011400	RF SCREENS	196.1784	196.1784	88.6063
1011400	RF SCREENS	196.1784	196.1784	88.6063
1011500	HDWRE BOX	419.6665	419.6665	706.0000
1011601	DUL GN BIPD	4053.5249	4053.5249	264.6799
1011602	HI GN RRGTRY	3013.9583	1635.0000	1382.7083
1011700	ATC BRACKETS	195.5908	195.5908	81.4469
1011700	ATC BRACKETS	195.5908	195.5908	81.4469
1011700	ATC BRACKETS	195.5908	195.5908	81.4469
1011700	ATC BRACKETS	195.5908	195.5908	81.4469
1020101	THR-UPR HAT	1712.0417	1712.0417	2332.0605
1020102	ATC-UPR HAT	378.9380	378.9380	177.0270
1020102	ATC-UPR HAT	378.9380	378.9380	177.0270
1020102	ATC-UPR HAT	378.9380	378.9380	177.0270
1020102	ATC-UPR HAT	378.9380	378.9380	177.0270
1020301	TEMP SENS-UB	18.3750	18.3750	0.0
1020401	TEMP SENS-LB	18.3750	18.3750	0.0
1020402	THR-LWR B/P	2109.2976	2109.2976	1509.1001
1020500	TH HEATERS	0.0	0.0	0.0
1030200	PITCH CON EL	3276.2295	663.6497	3596.9761
1030301	DETECTORS	468.5332	814.1331	576.5332
1030301	DETECTORS	468.5332	814.1331	576.5332
1030302	ELECTRONICS	250.7771	481.7769	522.6831
1030302	ELECTRONICS	250.7771	481.7769	522.6831
1030401	NUT DAMPER	6732.6992	6732.5977	7067.2773
1030402	ATT COIL	2288.2500	2288.2500	3901.5800
1030500	PITCH COIL	1231.6001	1310.8999	1310.8999
1030701	MOTOR ASSY	6399.4844	6399.4844	121.4235
1030702	INERTIA WHL	10147.7695	10147.7695	2441.6201
1030800	WHL HOR SENS	573.9448	573.9448	16.8900
1030900	MWA SHIELD	688.7336	688.7336	13.0680
1040100	UPPER SOL AR	15794.9453	15794.9453	20795.5156
1040200	LOWER SOL AR	20766.0039	20766.0039	20916.5000

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ORIGINAL PAGE IS OF POOR QUALITY

1041301	BATT 1	7924.4687	852.3027	7401.2344
1041302	BATT 2	1154.9277	7164.5687	6994.3594
1041401	PWR SUPL FL	9545.4102	808.9246	9547.3867
1051106	TORSS RDNDR	6903.1914	2871.4136	5418.9687
1051306	RPGNDR CABLE	998.5752	299.6382	763.8767
1051500	LOW GAIN ANT	4550.1914	4550.1914	1.0937
1051600	HI. GAIN ANT	9447.7305	5883.8039	5282.4531
1051806	SW+FLT NTwRK	710.2866	404.2659	644.9426
1051990	PREMOD PROC	2429.7031	819.5437	2245.4968
1061106	CTP	1623.5769	2829.3625	1586.5032
1061206	CDU	4778.2305	3178.8064	4074.5249
1061306	RTM	4414.9766	1668.5045	3870.3742
1061406	TAPE RECORDR	2637.4790	5169.0625	3010.4165
1061406	TAPE RECORDR	2637.4790	5169.0625	3010.4165
1061106	UPPER HARN	11808.3828	11808.3828	17187.5000
1061206	LOWER HARN	11808.3828	11808.3828	17187.5000
1061306	GROUND BLOCK	117.3583	117.3583	141.2000
1061406	GROUND BLOCK	88.0187	88.0187	105.9000
1061506	POTTING	293.3958	293.3958	353.0000
1061606	CLAMPS	293.3958	293.3958	353.0000
1061706	MAT	1613.6770	1613.6770	1941.5000
1061806	GRND STRAP	440.0935	440.0935	529.5000
1091102	PREAMPS	63.8339	308.3891	274.7920
1091102	PREAMPS	91.5539	308.3891	302.5120
1091102	PREAMPS	101.8059	216.5059	261.9058
1091102	PREAMPS	222.6604	128.5059	295.5603
1091102	PREAMPS	101.8059	216.5059	261.9058
1091102	PREAMPS	101.8059	216.5059	261.9058
1091103	ELECTRONICS	3369.6355	1123.7874	2369.8479
1091104	DISPENSER	1714.9436	4517.0117	2876.4736
1091104	DISPENSER	1714.9436	4517.0117	2876.4736
1091104	DISPENSER	912.6936	912.6936	1693.8876
1091104	DISPENSER	912.6936	912.6936	1693.8876
1091104	DISPENSER	912.6936	912.6936	1693.8876
1091104	DISPENSER	912.6936	912.6936	1693.8876
1091201	SENSOR	73.9338	1269.4697	1331.3582
1091202	ELECTRONICS	1911.4604	1325.0835	1375.2954
1091203	THRML BLNKT	0.0	0.0	0.0
1091301	ELECTRONICS	918.1042	1916.9080	1675.1018
1091302	SENSOR	698.8079	2630.2642	2026.0486
1091401	DETECTORS	7824.7422	7824.7422	156.4259
1091402	SCAN PLATE	1512.0728	1512.0728	56.3500
1091403	TOP PLATE	839.2776	839.2776	19.6000
1091406	HDWRE	209.0684	209.0684	10.5625
1091407	CABLING	627.2051	627.2051	31.6875
1091408	PPS	836.2734	836.2734	42.2500
1091408	PPS	836.2734	836.2734	42.2500
1091409	HVPS	501.7639	501.7639	25.3500
1091409	HVPS	501.7639	501.7639	25.3500
1091410	EPD SYST	209.0684	209.0684	10.5625
1091411	CEP	2508.8208	2508.8208	126.7500
1091412	HV DIVN	418.1367	418.1367	21.1250
1091413	THR BLNKT	83.6273	83.6273	4.2250
1091414	MAG SENSOR	862.9867	862.9867	1.5000
1091415	MAG DEPLOYER	871.1179	871.1179	8.4219
1091501	ELECTRONICS	260.6797	2584.4307	2584.4307
1091502	INSTRUMENT	327.9116	3547.7136	3552.9783
1091601	ELECTRONICS	3782.1753	841.8457	2987.8960
1091602	INSTRUMENT	3921.3083	3140.9939	4361.0781
1091603	CABLING	130.4198	29.0291	103.8248

1090701	ELECTRONICS	1279.1079	2259.5715	1991.9880
1090702	SENSOR	1482.4934	4654.2344	3347.5776
1090801	SIG PROC	1691.9038	1015.1729	1731.6807
1090802	FILTER BOX	393.2913	55.4143	342.6223
1090802	FILTER BOX	393.2913	55.4143	342.6223
1090803	LATCH	157.3166	22.1657	137.0489
1090803	LATCH	157.3166	22.1657	137.0489
1090804	PROBE	188.1724	18.1308	170.0428
1090804	PROBE	188.1724	18.1308	170.0428
1090805	CABLING	104.7162	37.4681	92.1640
1090901	ELECTRONICS	1185.3528	2835.5681	1830.2158
1090902	SENSOR	774.3494	2914.1550	2243.4939
1100200	MAG BAL	213.4385	2908.7017	3129.7651
1300101	ASTROMAST	130.2274	810.7268	911.9163
1300102	ASTRO MOVR	654.6123	4075.2727	4583.9141
1300200	HARNESS MAG	89.6960	558.3999	628.0957
1300301	MTG PLATE	1541.3252	1541.3252	191.9479
1300302	DRIVE	503.1111	503.1111	10.5750
1300303	IFCE ELECTR	834.0266	1061.6780	987.7910
1300304	DRIVE ELECTR	1382.1011	1759.3521	1636.0823

DYNAMICS EXPLORER DE-B
S/C MOMENTS OF INERTIA
01 OCTOBER 1978

THE TOTALS BEFORE BALANCING ARE-

SUM OF WEIGHTS= 0.75570483E+03
SUM OF WEIGHT * X DISTANCE=-0.34031836E+03
SUM OF WEIGHT * Y DISTANCE= 0.47448853E+02
SUM OF WEIGHT * Z DISTANCE=-0.18318710E+02
SUM OF WEIGHT * X * Z DISTANCES= 0.10470796E+04
SUM OF WEIGHT * Y * Z DISTANCES= 0.57751936E+04
SUM OF WEIGHT * Y * Y DISTANCES= 0.49899731E+03
SUM OF WEIGHT * X2= 0.62911859E+05
SUM OF WEIGHT * Y2= 0.54924953E+05
SUM OF WEIGHT * Z2= 0.12138919E+06

SUM OF IXX= 0.94977750E+05
SUM OF IYY= 0.91703562E+05
SUM OF IZZ= 0.15978447E+06

THE C.G. COMPONENTS ARE-- X= -0.449737E+00 Y= 0.627046E-01 Z= -0.242085E-01

SUM OF IYY= 0.67172394E+02
SUM OF IXZ= 0.0
SUM OF IYZ= 0.0

DYANICS EXPLORER DE-B
S/C MOMENTS OF INERTIA
01 OCTOBER 1978

S/C MOMENTS OF INERTIA ARE-

* THE FOLLOWING VALUES HAVE UNITS OF LB.-IN2
IX= 0.27619137E+06
IY= 0.27585100E+06
IZ= 0.2823.556E+06
IYZ= 0.1338408E+04
IXZ= 0.57753320E+04
IXY= 0.57956903E+03
IMAX= 0.27661875E+06
IMIN= 0.27561356E+06

* THE FOLLOWING VALUES HAVE UNITS OF IN-LBS-SEC2
IXX= 0.71542139E+03
IYY= 0.71456567E+03
IZZ= 0.73144092E+03
IYZ= 0.2491018IE+01
IXZ= 0.1495.303AE+02
IXK= 0.15011625E+01
IMAX= 0.71655444E+03
IMIN= 0.71343262E+03

INERTIA RATIO

$I_{SPIN}/I_{TRANSVERSE\ MAX} = 1.021$

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APPENDIX D

DE-B DEPLOYED MASS PROPERTIES

COMPUTER OUTPUT

TBS

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No.
DYNAMICS EXPLORER	2.4.4-003-DN

Title

DE RADIATION ENVIRONMENT ANALYSIS

Written by:	Date
G. Brucker/R. Ohanian	June 1, 1978
Approved by: W. F. Fuldner	Date 6 June '78
This DN supplements (S), replaces (R) DN Nos. Supersedes 2.4.4-001-DN, 9/9/77 Addition 9/27/78 ( ) ( )	

REVISIONS

Letter	Description	Date	Author
A	Addition of Para. 6.0, Table 4, and Figure 5.	9/27/78	R. Ohanian

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AE 1338-2 1/74

1.0 INTRODUCTION

This design note supersedes 2.4.4-001-DN, an earlier radiation environment analysis submitted for Dynamics Explorer (1). The orbital parameters for the A and B missions have been modified and new environmental models have become available since the latter design note was issued. The current work incorporates all these changes and compares the new results with the previous results.

The environments for Dynamics Explorer A and B have been evaluated in a 1981 time frame (Solar Maximum conditions) utilizing the minimum drag orbit parameters ("Flux = 150" case) received from NASA. Minimum drag was chosen because it is a worst case condition by virtue of slower altitude decay. Results are presented here in a context of nominal mission life (13 months) and expected maximum life (97 weeks, after which the B orbit is expected to be fully decayed).

The data processing for this report is similar to that of previous work. First, the A and B orbits described in Reference (2) were constructed on an RCA orbit generating computer program by means of appropriate drag coefficients. Next, twenty-four hour "snapshots" of each orbit (two minute step size), corresponding to 16 week intervals, were placed on a disk file. Each snapshot was then processed in normal fashion using B-L conversion and radiation model programs originally obtained from E. Stassinopoulos (NASA/GSFC). Finally, the resulting snapshot environments were properly weighted, combined, and submitted to RCA's UNIDOSE and Solar Cell Damage Equivalence computer codes. It should be noted, however, that the present study utilized newly received maps for inner and outer zone trapped electrons; in particular the AE17-HI map, which is a significant change for the outer zone, was used herein for worst case conservatism.

2.0 DOSE-DEPTH SHIELDING CURVES

Figures 1 and 2 contain the total worst case curves of ionization dose vs. equivalent aluminum thickness (spherical shield geometry) for the A and B spacecraft respectively. Note two solid curves in each figure (corresponding to the 97 week and 13 month durations of this present analysis), and a dashed curve which is taken from the worst case of the previous design note (2.4.4-001-DN).

To achieve a worst case for both A and B, the present study has applied a factor of two in uncertainty to the trapped proton contribution (AP8-MAX map), and has utilized the 99% confidence level for solar protons (solar alphas levels are approximated at 5% of the solar protons). However, for the trapped electrons, differing uncertainties were applied to the A and B spacecraft. In the case of DE-A, nearly the entire orbit falls within the outer zone, and because of the severe AE17-HI environment, a factor of unity is adequate. On the other hand, owing to the large inner zone component, a factor of three was applied to the DE-B trapped electron (and accompanying Bremsstrahlung) contribution.

The resulting curves, coupled with a knowledge of spherical shielding geometry, enable one to design against the expected long-term dose encountered on-board the spacecraft. For simple or non-critical geometries, it may be possible to estimate the dose by hand. However, shielding geometry computer codes of excellent accuracy are available at RCA/AE if the need arises.

3.0 EQUIVALENT FLUENCE VS. SHIELDING CURVES

Figures 3 and 4 contain the worst case equivalent 1 MeV electron fluence vs. shield thickness curves for the A and B spacecraft respectively. These curves were produced under the same conditions as the dose-depth curves discussed above, and can be applied to spherical geometries to obtain long term bulk damage in semiconductor components (excepting solar cells - see below).

4.0 SOLAR CELL DEGRADATION PARAMETERS

The worst case equivalent 1 MeV electron fluences for evaluating end-of-life I_{sc} (short circuit currents) and P_{max} or V_{oc} (maximum power or open circuit voltage) for the A and B missions, along with the corresponding worst case results from 2.4.4-001-DN, are contained in Table 1. These results were calculated under the conditions outlined above, and are appropriate for a cover glass of 60 mils (fused silica) and infinite backshielding.

5.0 PEAK FLUXES

In general, the peak flux rate of a particle type at a given energy is about two orders of magnitude more severe than the long term average rate. Accordingly, Tables 2 and 3 contain a peak flux spectrum (a factor of 100 greater than the long-term average rate) for the A and B missions respectively. If interested, the reader may refer to 2.4.4-001-DN for the previous results, which were not presented in spectrum form and were obtained by using a slightly different criteria.

Peak rates are necessary when considering circuits which can be upset by short term (transient) conditions. However, one must be sure he is evaluating the correct transient mechanism. Tables 2 and 3 are useful if individual particle rates cause system upset (such as spurious counts in a sensor). On the other hand, peak rates for dose or equivalent 1 MeV electron fluence may be estimated from the information provided in the previous sections of this report: merely divide the long term dose (or fluence) by the appropriate time factor to obtain dose (or fluence) per second and multiply by 100 to achieve the two order of magnitude increase.

6.0 EXTENDED TABLE OF SOLAR CELL DAMAGE EQUIVALENCE

Table 4 and Figure 5 contain the results of a study which extends the results of paragraph 4.0 to cover glass thicknesses other than 60 mils.

REFERENCES:

(1) G. Brucker and R. Ohanian, "DE Radiation Analysis", Dynamics Explorer design note 2.4.4-001-DN, September 9, 1977.

(2) Letter from F. Carr (NASA/GSFC) to W. V. Fuldner, File #11128, May 12, 1978.

TABLE 1.

SOLAR CELL DAMAGE EQUIVALENCE (worst case total, 60 mil cover glass, infinite backshielding)

	I_{sc} (1 MeV electron fluence)	P_{max} or V_{oc} (1 MeV electron fluence)
A mission, 97 wks.	1.76×10^{14}	2.32×10^{14}
A mission, 13 mos.	9.56×10^{13}	1.25×10^{14}
A mission, 2.4.4-001-DN (1.8 yrs)	3.08×10^{14}	4.28×10^{14}
B mission, 97 wks.	2.93×10^{13}	3.49×10^{13}
B mission, 13 mos.	2.16×10^{13}	2.56×10^{13}
B mission, 2.4.4-001-DN (1.8 yrs)	8.76×10^{12}	1.06×10^{13}

TABLE 2.

Peak Flux Spectrum for DE-A

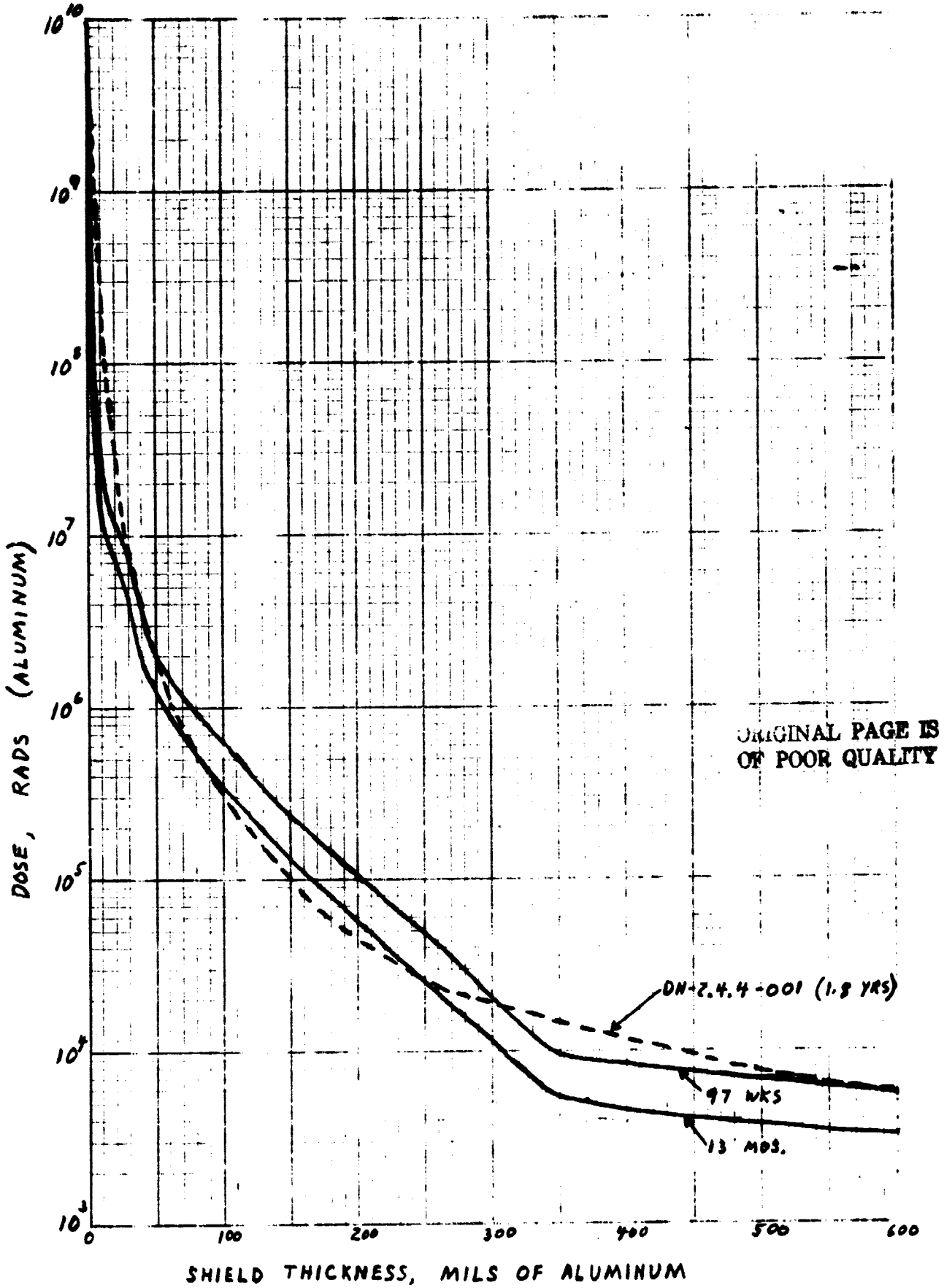
Energy (MeV)	Protons ($p/cm^2/sec >$ Energy)	Electrons ($e/cm^2/sec >$ Energy)
.1	1.90×10^9	1.52×10^9
1.0	1.39×10^8	9.90×10^7
5.0	3.39×10^6	7.94×10^5
10.0	6.29×10^5	0
50.0	2.61×10^4	0
100.0	1.05×10^4	0

TABLE 3.

Peak Flux Spectrum for DE-B

Energy (MeV)	Protons ($p/cm^2/sec >$ Energy)	Electrons ($e/cm^2/sec >$ Energy)
.1	3.65×10^6	6.84×10^7
1.0	2.98×10^5	9.21×10^5
5.0	9.19×10^4	9.25×10^3
10.0	7.04×10^4	0
50.0	1.87×10^4	0
100.0	8.29×10^3	0

DOSE VS. SHIELDING FOR DE-A



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FIG. 1

DOSE VS. SHIELDING FOR DE-B

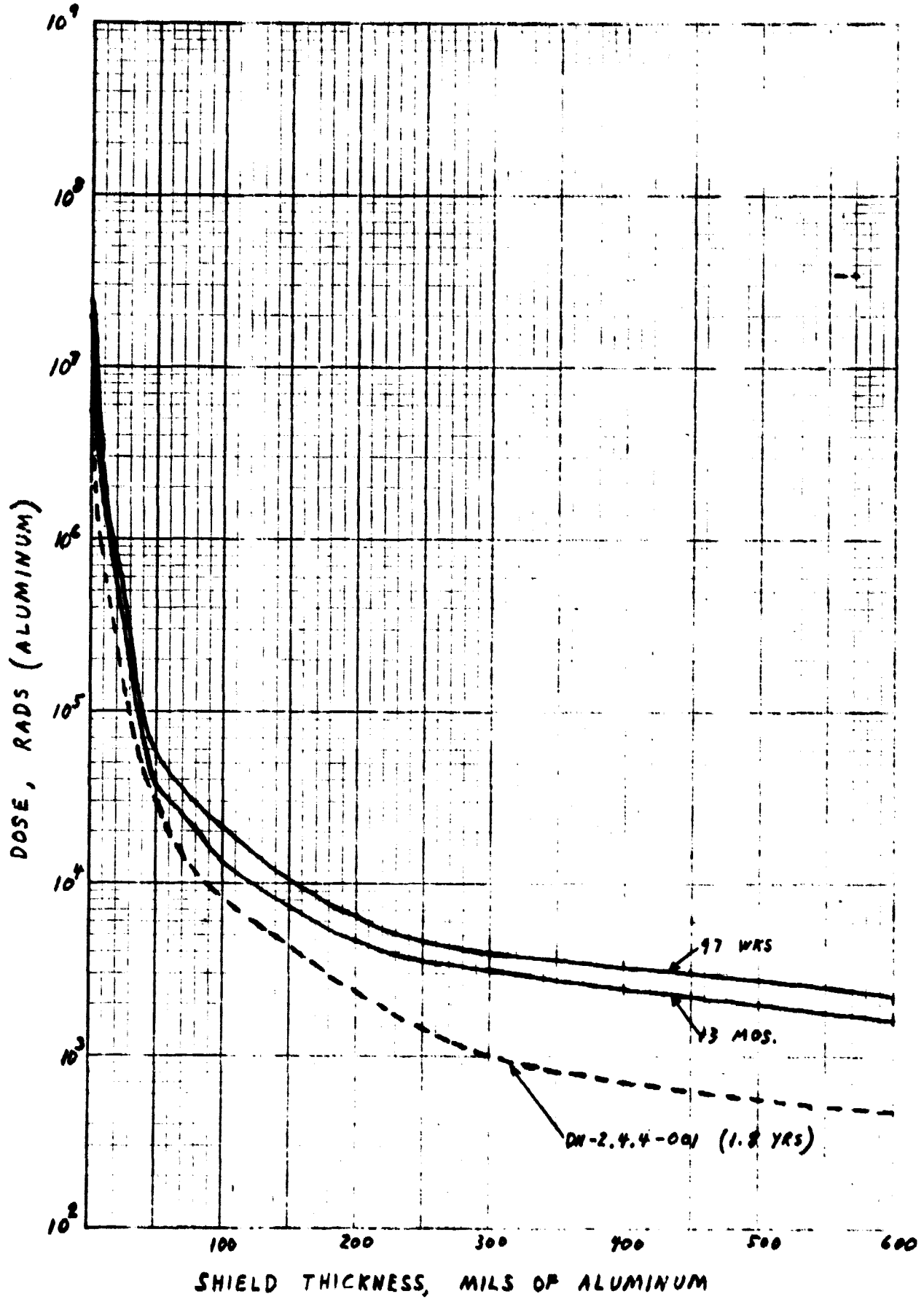


FIG. 2

EQUIVALENT FLUENCE VS. SHIELDING FOR DE-A

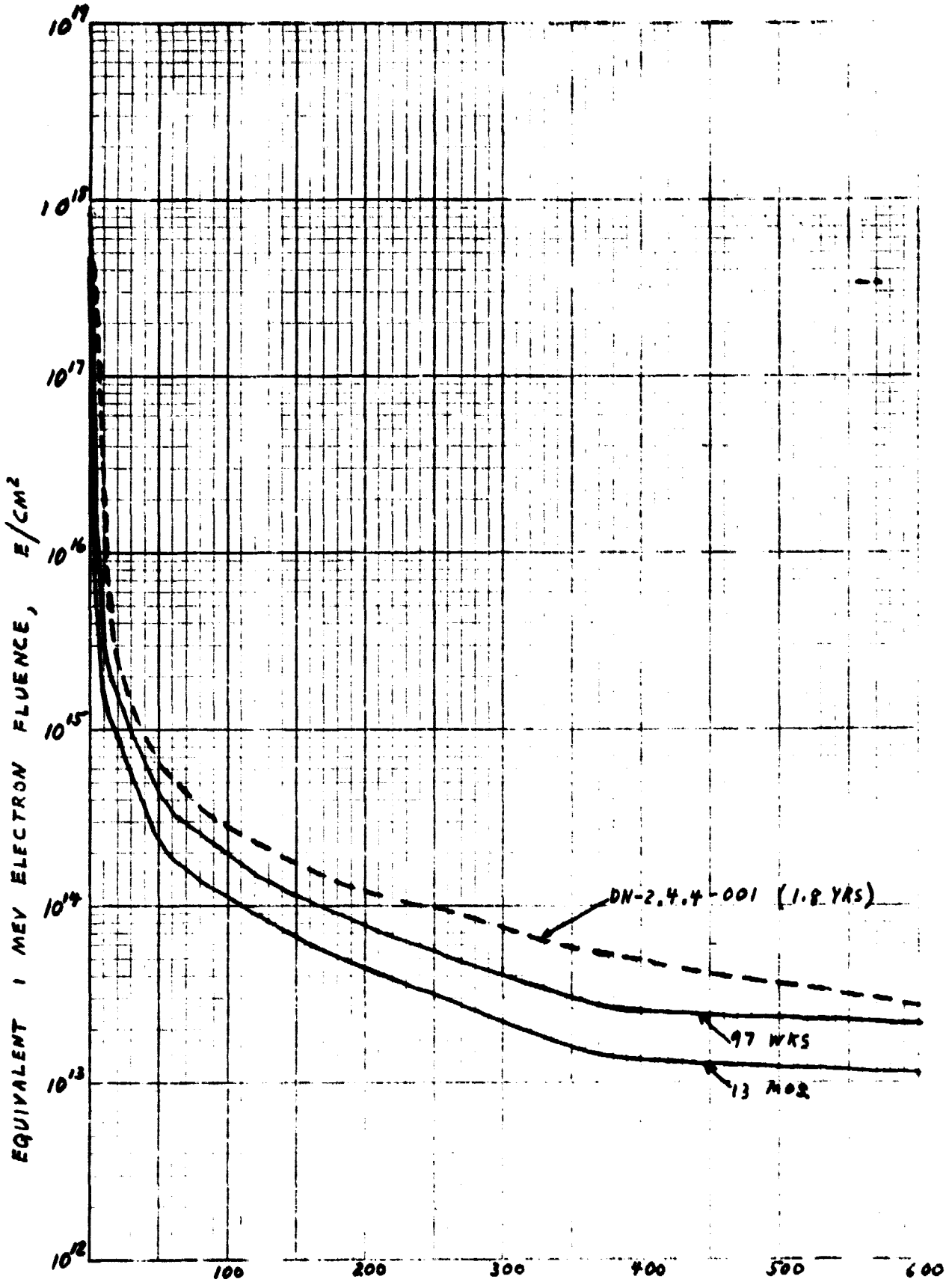


FIG. 3

EQUIVALENT FLUENCE VS. SHIELDING FOR DE-B

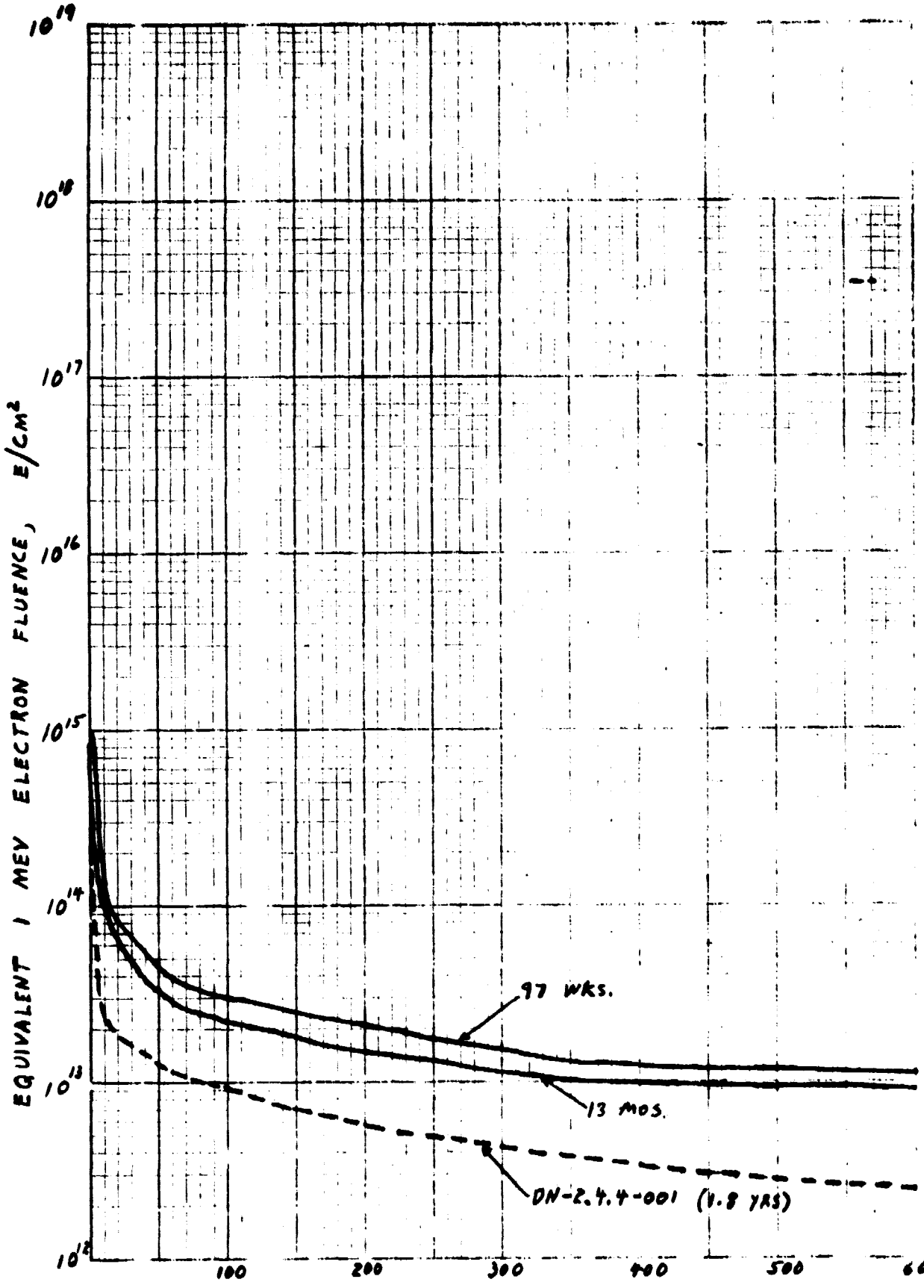


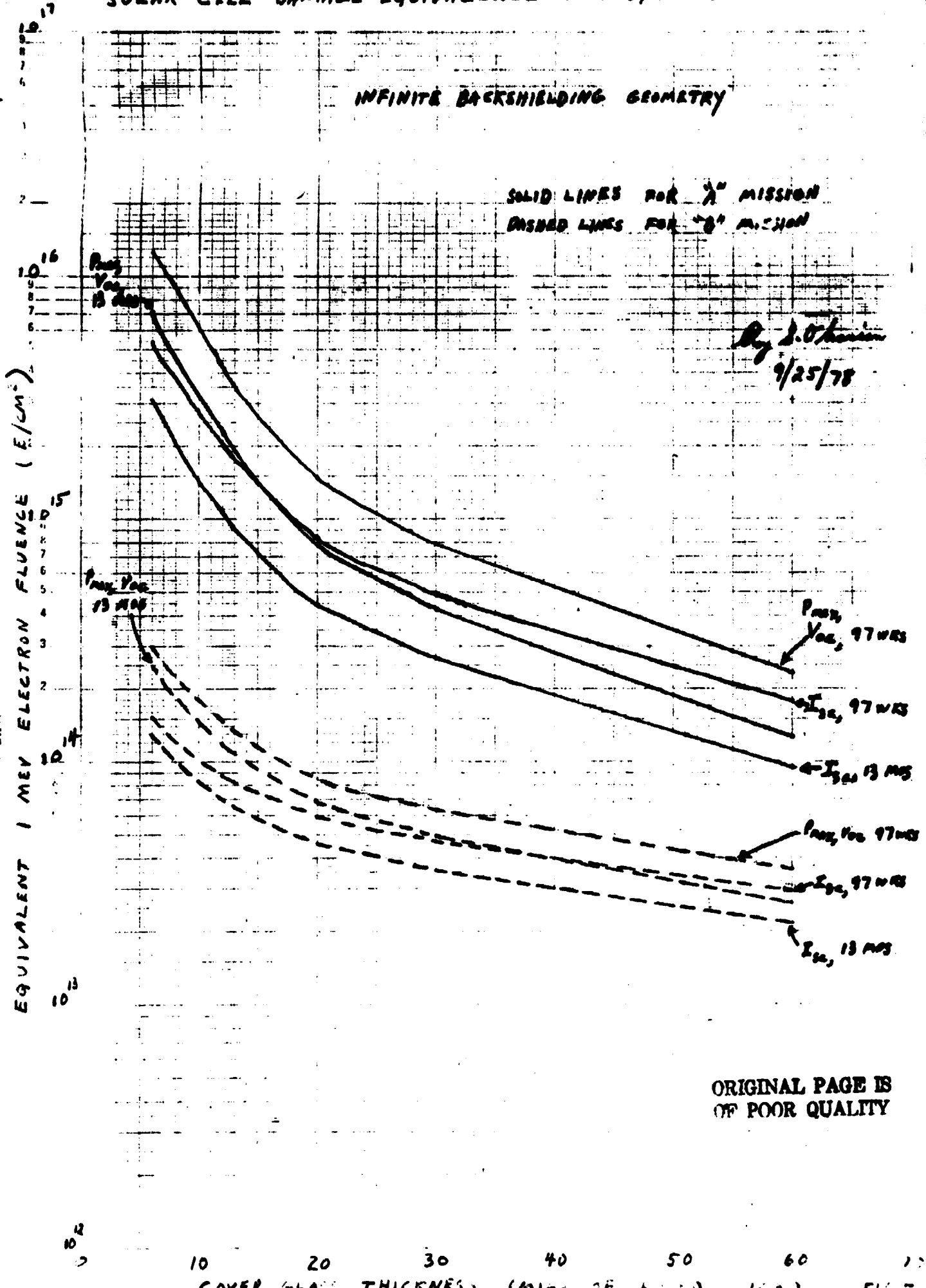
FIG. 4

TABLE 4.

EXTENDED TABLE OF SOLAR CELL DAMAGE EQUIVALENCE
(1 MeV Equivalent electrons/cm^2, Worst Case Total,
Infinite Backshielding)

Mission/Parameter	Cover Glass Thickness, Mils of Fused Silica				
	6	12	20	30	60
"A", 97 wks, I_{sc}	5.36×10^{15}	1.99×10^{15}	8.30×10^{14}	4.87×10^{14}	1.76×10^{14}
"A", 97 wks, P_{max} or Voc	1.25×10^{16}	4.17×10^{15}	1.46×10^{15}	7.99×10^{14}	2.32×10^{14}
"A", 13 mos, I_{sc}	3.08×10^{15}	1.06×10^{15}	4.43×10^{14}	2.61×10^{14}	9.56×10^{13}
"A", 13 mos, P_{max} or Voc	7.15×10^{15}	2.21×10^{15}	7.78×10^{14}	4.27×10^{14}	1.25×10^{14}
"B", 97 wks, I_{sc}	1.52×10^{14}	8.73×10^{13}	5.94×10^{13}	4.68×10^{13}	2.93×10^{13}
"B", 97 wks, P_{max} or Voc	2.91×10^{14}	1.44×10^{14}	8.47×10^{13}	6.37×10^{13}	3.49×10^{13}
"B", 13 mos, I_{sc}	1.26×10^{14}	6.98×10^{13}	4.58×10^{13}	3.53×10^{13}	2.16×10^{13}
"B", 13 mos, P_{max} or Voc	2.47×10^{14}	1.18×10^{14}	6.67×10^{13}	4.88×10^{13}	2.56×10^{13}

SOLAR CELL DAMAGE EQUIVALENCE FOR DYNAMIC EXPLORER



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4.0 THERMAL SUBSYSTEM DESIGN NOTES

TABLE OF CONTENTS

Design Note	Title
3.2.2-001-DN	DE-A Thermal Model Description
3.2.2-002-DN	DE-B Simplified Thermal Model Description
3.2.2-003-DN	DE-A Baseline Thermal Model Performance and Analysis
3.2.2-004-DN	DE-A Parametric Thermal Study
3.2.2-005-DN	DE-A Final Thermal Design Configuration
3.2.2-006-DN	DE-B Parametric Thermal Study and Performance
3.2.2-007-DN	LAPI/Scan Platform Thermal Model Description and Performance
3.2.2-008-DN	DE-A ATC Thermal Design Performance
3.2.2-009-DN	Thermal Interface for Booms and Antennas for the DE-A and DE-B Spacecraft
3.2.2-010-DN	DE-A and DE-B Thermal Design Hardware Summary

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No.
	3.2.2-001-DN

Title

DE-A THERMAL MODEL DESCRIPTION

Written by C. Chhatpar	Date 9/27/78
Approved by W. V. Fuldner	Date 10 Oct 78
This DN supplements (S), replaces (R) DN Nos ( ) ( )	

REVISIONS

Letter	Description	Date	Author

Standard Distribution:
R. deBastos
W. Fuldner
G. Hogan
W. Hord
C. Hume
D. Shipley

1. SUMMARY

A 24 node steady state thermal model has been developed to evaluate the parametric performance of the DE-A spacecraft. The model provides data to compute orbit-average temperatures as functions of sun angle and duty cycles of variable dissipating components. The program automatically computes variable radiation couplings of internal nodes to external surroundings as a function of ATC positions which are dependent upon the baseplate temperatures.

2. DETAILS

The details of the model are contained in the following tables:

Item	Title
Table 1	Node Identification
Table 2	External Sink Identification
Table 3	External Sink Thermophysical Properties
Table 4	Orbit Average External Sink Values
Table 5	Spacecraft Internal and External Couplings
Table 6	DE-A Thermal Power Configuration
Table 7	Shunt Power Distribution
Table 8	DE-A Nodal Power Distribution: 100% Duty Cycle
Table 9	DE-A Nodal Power Distribution: 67.5% Duty Cycle
Table 10	DE-A Nodal Power Distribution: 33.75% Duty Cycle
Table 11	DE-A Nodal Power Distribution: 0% Duty Cycle

TABLE 1. NODE IDENTIFICATION

Node No.	Description
1	Upper Baseplate - Equipment Complex
2	Lower Baseplate - Equipment Complex
3	Top - ATC Area
4	Top - Passive Area
5	Bottom - ATC Area
6	Bottom - Passive Area
7	Separation Adapter - Lower
8	PWI Lower
9	Thermal Shield Lower
10	Upper Side Array - Quadrant 1
11	Upper Side Array - Quadrant 2
12	Upper Side Array - Quadrant 3
13	Upper Side Array - Quadrant 4
14	Lower Side Array - Quadrant 1
15	Lower Side Array - Quadrant 2
16	Lower Side Array - Quadrant 3
17	Lower Side Array - Quadrant 4
18	S-band Antenna - Quadrant 1
19	S-band Antenna - Quadrant 2
20	S-band Antenna - Quadrant 3
21	S-band Antenna - Quadrant 4
22	Separation Adapter - Upper
23	PWI - Upper
24	Thermal Shield - Upper

TABLE 2. EXTERNAL SINK IDENTIFICATION

Sink No.	Description
1	Spacecraft Top
2	Upper Side Array - Quadrant 1
3	Upper Side Array - Quadrant 2
4	Upper Side Array - Quadrant 3
5	Upper Side Array - Quadrant 4
6	Lower Side Array - Quadrant 1
7	Lower Side Array - Quadrant 2
8	Lower Side Array - Quadrant 3
9	Lower Side Array - Quadrant 4
10	Spacecraft Bottom
11	S-band Antenna - Quadrant 1
12	S-band Antenna - Quadrant 2
13	S-band Antenna - Quadrant 3
14	S-band Antenna - Quadrant 4
15	Upper Baseplate - Experiment Ports
16	Lower Baseplate - Experiment Ports
17	Space

TABLE 3. EXTERNAL SINK THERMOPHYSICAL PROPERTIES

Sink No.	Properties Solar Absorptance BOL	Solar Absorptance EOL	IR Emittance
1	.725	.763	.81
2	.622	.635	.722
3	.622	.635	.722
4	.622	.635	.722
5	.622	.635	.722
6	.622	.635	.722
7	.622	.635	.722
8	.622	.635	.722
9	.622	.635	.722
10	.725	.763	.81
11	.305	.455	.274
12	.305	.455	.274
13	.305	.455	.274
14	.305	.455	.274
15	.764	.764	.603
16	.857	.857	.732
17	1.0	1.0	1.0

TABLE 4. ORBIT-AVERAGE EXTERNAL SINK VALUES FOR DE-A SPACECRAFT (HIGH-ALTITUDE MISSION)

Sink No.	Sink Equivalent Black-Body Radiation (Watts/Sq-In)									
	BOL - 10 rpm Apogee = 23918 km Perigee = 275 km					EOL - 10 rpm Apogee = 23918 km Perigee = 275 km				
	Orbit Sun Angle (deg)					Orbit Sun Angle (deg)				
	0	45	90	-45	-0	0	45	90	-45	-0
1	0.004	0.006	0.008	0.578	0.812	0.002	0.003	0.005	0.604	0.852
2	0.008	0.187	0.199	0.187	0.008	0.005	0.186	0.203	0.186	0.005
3	0.008	0.187	0.199	0.187	0.008	0.005	0.186	0.203	0.186	0.005
4	0.008	0.187	0.199	0.187	0.008	0.005	0.186	0.203	0.186	0.005
5	0.008	0.187	0.199	0.187	0.008	0.005	0.186	0.203	0.186	0.005
6	0.008	0.187	0.199	0.187	0.008	0.005	0.186	0.203	0.186	0.005
7	0.008	0.187	0.199	0.187	0.008	0.005	0.186	0.203	0.186	0.005
8	0.008	0.187	0.199	0.187	0.008	0.005	0.186	0.203	0.186	0.005
9	0.008	0.187	0.199	0.187	0.008	0.005	0.186	0.203	0.186	0.005
10	0.812	0.578	0.008	0.006	0.004	0.852	0.604	0.005	0.003	0.002
11	0.008	0.24	0.255	0.24	0.008	0.005	0.347	0.379	0.347	0.005
12	0.008	0.24	0.255	0.24	0.008	0.005	0.347	0.379	0.347	0.005
13	0.008	0.24	0.255	0.24	0.008	0.005	0.347	0.379	0.347	0.005
14	0.008	0.24	0.255	0.24	0.008	0.005	0.347	0.379	0.347	0.005
15	0.008	0.272	0.289	0.272	0.008	0.005	0.266	0.29	0.266	0.005
16	0.008	0.252	0.268	0.252	0.008	0.005	0.246	0.268	0.246	0.005
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 5. SPACECRAFT INTERNAL AND EXTERNAL COUPLING

Internal Coupling							
From	To	Radiative Coupling (in^2)	Conductive Coupling (watts/°C)	From	To	Radiative Coupling (in^2)	Conductive Coupling (watts/°C)
1	2	737.0	VAR (2)	2	18	3.6	--
1	3	VAR (1)	--	2	19	3.6	--
1	4	31.65	--	2	20	3.6	--
1	10	27.6	.028	2	21	3.6	--
1	11	27.6	.028	3	4	2.5	.65
1	12	27.6	.028	3	10	VAR (1)	--
1	13	27.6	.028	3	11	VAR (1)	--
1	14	7.7	--	3	12	VAR (1)	--
1	15	7.7	--	3	13	VAR (1)	--
1	16	7.7	--	3	22	VAR (1)	--
1	17	7.7	--	4	10	.36	.5
1	18	3.6	--	4	11	.36	.5
1	19	3.6	--	4	12	.36	.5
1	20	3.6	--	4	13	.36	.5
1	21	3.6	--	4	22	7.75	.1
1	22	VAR (1)	1.26	5	5	2.5	.65
2	5	VAR (1)	--	5	7	VAR (1)	--
2	6	31.65	--	5	14	VAR (1)	--
2	7	VAR (1)	1.26	5	15	VAR (1)	--
2	10	7.7	--	5	16	VAR (1)	--
2	11	7.7	--	5	17	VAR (1)	--
2	12	7.7	--	6	7	7.75	.1
2	13	7.7	--	6	14	.36	.5
2	14	27.6	.024	6	15	.36	.5
2	15	27.6	.024	6	16	.36	.5
2	16	27.6	.024	6	17	.36	.5
2	17	27.6	.024	7	8	224.2	.2

TABLE 5. SPACECRAFT INTERNAL AND EXTERNAL COUPLING - Continued

Internal Coupling							
From	To	Radiative Coupling (in^2)	Conductive Coupling (watts/°C)	From	To	Radiative Coupling ( )	Conductive Coupling (watts/°C)
7	9	6.2	--	14	15	--	.04
7	14	13.0	--	14	15	--	.04
7	15	13.0	--	14	18	--	.09
7	16	13.0	--	15	16	--	.04
7	17	13.0	--	15	19	--	.09
8	9	3.0	--	16	17	--	.04
10	22	13.0	--	16	20	--	.09
10	11	--	.04	17	21	--	.09
10	13	--	.04	18	19	--	.027
10	18	--	.09	18	21	--	.027
11	12	--	.04	19	20	--	.027
11	19	--	.09	20	21	--	.027
11	22	13.0	--	22	23	224.2	.2
12	13	--	.04	22	24	6.2	--
12	20	--	.09	23	24	3.0	--
12	22	13.0	--				
13	21	--	.09				
13	22	13.0	--				

NOTES: (1) Variable as a function of louver position and sun angle.

(2) Varied parametrically depending on configuration (with or without heat pipes or shear web thickness).

TABLE 5. SPACECRAFT INTERNAL AND EXTERNAL COUPLINGS

External Coupling					
From	To	Radiative Coupling (in^2)	From	To	Radiative Coupling (in^2)
Node	Sink		Node	Sink	
1	15	36.783	14	6	633.9
1	17	VAR (1)	15	7	633.9
2	16	62.519	16	8	633.9
2	17	VAR (1)	17	9	633.9
3	1	802.5	18	11	34.4
4	1	752.1	19	2	34.4
5	10	802.5	20	13	34.4
6	10	752.1	21	14	34.4
7	17	9.5	22	17	9.5
8	17	4.9	23	17	4.9
9	17	10.0	24	17	10.0
10	2	633.9			
11	3	633.9			
12	4	633.9			
13	5	633.9			

NOTE: (1) Varied as a function of cutouts in the end array for the ATC's.

TABLE 6. DE-A THERMAL POWER CONFIGURATION

Instrument/Box	Internal Power Distribution (Watts)										
				at 100% Duty Cycle		at 67.5% Duty Cycle		at 33.75% Duty Cycle		at 0% Duty Cycle	
	Continuous	Science	Playback	Science (89%)	Playback (11%)	Science (60%)	Playback (7.5%)	Science (30%)	Playback (3.75%)	Science	Playback
Upper Baseplate											
SAI		2.5		2.22		1.5		0.75			
EIC		7.0		6.23		4.2		2.1			
PWI PWI (Electronics)		7.8		6.94		4.68		2.34			
RIMS + RIMS (Electronics)		10.5		9.35		6.3		3.15			
MAG Electronics		3.5		3.12		2.1		1.05			
TR (TU + EU)		10.0	21.0	8.90	2.31	6.0	1.58	3.0	0.79		
Thermal	2.0										
SUBTOTAL	2.0	41.3	21.0	36.76	2.31	24.78	1.58	12.39	0.79	0	0
Lower Baseplabe											
BHS	3.15										
RIMS (1 + 2)		6.0		5.34		3.6		1.8			
HAPI		10.0		8.90		6.0		3.0			
SAI + SAI		5.0		4.45		3.0		1.5			
Battery 1 & 2											
PSE	3.0										
PMP	1.6										
RTM	1.0										
CTP/CDU	2.5										
RTX-A	6.8		17.3		1.9		1.3		0.65		
Thermal	2.0										
SUBTOTAL	20.05	21.0	17.3	18.69	1.9	12.6	1.3	6.3	0.65	0	0
TOTAL	22.05	62.3	38.3								

TABLE 7. SHUNT POWER DISTRIBUTION

	Power Fraction
Node	Trans and Shunt
1	-
2	-
3	-
4	.16
5	-
6	.16
7	-
8	-
9	-
10	.079
11	.091
12	.091
13	.079
14	.079
15	.091
16	.091
17	.079
18	-
19	-
20	-
21	-
22	-
23	-
24	-

TABLE 8. DE-A NODAL POWER DISTRIBUTION

100% Duty Cycle [89% Science + 11% PB]

NODE	INTERNAL DISSIPATION			SHUNT POWER + BATTERY + PSE					ABSORBED HEAT FLUX NOT ACCOUNTED FOR					TOTAL Q				
	CONSTANT	SCIENCE	PB	11.67°	45°	90°	-45°	-11.67°	11.67	45°	90°	-45°	-11.67°	11.67°	45°	90°	-45°	-11.67°
1	2.0	36.76	2.31	-	-	-	-	-						41.07	41.07	41.07	41.07	41.07
2	20.05	18.69	1.9	8.68	9.62	9.4	9.59	10.03						49.29	50.23	50.01	50.2	50.64
3				-	-	-	-	-						-	-	-	-	-
4				1.71	3.59	.45	2.96	.54						1.71	3.59	.45	2.96	.54
5				-	-	-	-	-						-	-	-	-	-
6				1.71	3.59	.45	2.96	.54						1.71	3.59	.45	2.96	.54
7				-	-	-	-	-	10.0	7.1	1.7	.2	.2	10.0	7.1	1.7	.2	.2
8				-	-	-	-	-	4.9	3.5	.1	.1	.1	4.9	3.5	.1	.1	.1
9				-	-	-	-	-	11.2	7.9	1.4	.1	.1	11.2	7.9	1.4	.1	.1
10				.84	1.77	.22	1.46	.27						.84	1.77	.22	1.46	.27
11				.97	2.04	.25	1.68	.31						.97	2.04	.25	1.68	.31
12				.97	2.04	.25	1.68	.31						.97	2.04	.25	1.68	.31
13				.84	1.77	.22	1.46	.27						.84	1.77	.22	1.46	.27
14				.84	1.77	.22	1.46	.27						.84	1.77	.22	1.46	.27
15				.97	2.04	.25	1.68	.31						.97	2.04	.25	1.68	.31
16				.97	2.04	.25	1.68	.31						.97	2.04	.25	1.68	.31
17				.84	1.77	.22	1.46	.27						.84	1.77	.22	1.46	.27
18				-	-	-	-	-						-	-	-	-	-
19				-	-	-	-	-						-	-	-	-	-
20				-	-	-	-	-						-	-	-	-	-
21				-	-	-	-	-						-	-	-	-	-
22				-	-	-	-	-	.2	.2	1.7	7.1	10.0	.2	.2	1.7	7.1	10.0
23				-	-	-	-	-	.1	.1	.1	3.5	4.9	.1	.1	.1	3.5	4.9
24				-	-	-	-	-	.1	.1	1.4	7.9	11.2	.1	.1	1.4	7.9	11.2

TABLE 9. DE-A NODAL POWER DISTRIBUTION

67.5% Duty Cycle [60% Science + 7.5% PB]

NODE	INTERNAL DISSIPATION			SHUNT POWER + BATTERY + PSE					ABSORBED HEAT FLUX NOT ACCOUNTED FOR					TOTAL Q				
	CONSTANT	SCIENCE	PB	11.67°	45°	90°	-45°	-11.67°	11.67	45°	90°	-45°	-11.67°	11.67°	45°	90°	-45°	-11.67°
1	2.0	24.78	1.58	-	-	-	-	-						28.36	28.36	28.36	28.36	28.36
2	20.05	10.38	1.3	6.46	7.19	9.32	9.26	9.05						38.19	38.92	41.05	40.99	40.78
3				-	-	-	-	-						-	-	-	-	-
4				5.17	7.11	.45	6.48	1.7						5.17	7.11	.45	6.48	1.7
5				-	-	-	-	-						-	-	-	-	-
6				5.17	7.11	.45	6.48	1.7						5.17	7.11	.45	6.48	1.7
7				-	-	-	-	-	10.0	7.1	1.7	.2	.2	10.0	7.1	1.7	.2	.2
8				-	-	-	-	-	4.9	3.5	.1	.1	.1	4.9	3.5	.1	.1	.1
9				-	-	-	-	-	11.2	7.9	1.4	.1	.1	11.2	7.9	1.4	.1	.1
10				2.55	3.51	.22	3.2	.84						2.55	3.51	.22	3.2	.84
11				2.94	4.04	.25	3.69	.97						2.94	4.04	.25	3.69	.97
12				2.94	4.04	.25	3.69	.97						2.94	4.04	.25	3.69	.97
13				2.55	3.51	.22	3.2	.84						2.55	3.51	.22	3.2	.84
14				2.55	3.51	.22	3.2	.84						2.55	3.51	.22	3.2	.84
15				2.94	4.04	.25	3.69	.97						2.94	4.04	.25	3.69	.97
16				2.94	4.04	.25	3.69	.97						2.94	4.04	.25	3.69	.97
17				2.55	3.51	.22	3.2	.84						2.55	3.51	.22	3.2	.84
18														-	-	-	-	-
19														-	-	-	-	-
20														-	-	-	-	-
21														-	-	-	-	-
22									.2	.2	1.7	7.1	10.0	.2	.2	1.7	7.1	10.0
23									.1	.1	.1	3.5	4.9	.1	.1	.1	3.5	4.9
24									.1	.1	1.4	7.9	11.2	.1	.1	1.4	7.9	11.2

TABLE 10. NE-A NODAL POWER DISTRIBUTION

33.75% Duty Cycle [30% Science + 3.75% PB]

NODE	INTERNAL DISSIPATION			SHUNT POWER + BATTERY + PSE					ABSORBED HEAT FLUX NOT ACCOUNTED FOR					TOTAL Q				
	CONSTANT	SCIENCE	PB	11.67°	45°	90°	-45°	-11.67°	11.67	45°	90°	-45°	-11.67°	11.67°	45°	90°	-45°	-11.67°
1	2.0	12.39	.79	-	-	-	-	-						15.18	15.18	15.18	15.18	15.18
2	20.05	5.19	.65	4.15	4.68	6.15	4.63	5.42						30.04	30.57	32.04	30.52	31.31
3				-	-	-	-	-						-	-	-	-	-
4				8.76	10.72	3.84	10.16	6.34						8.76	10.72	3.84	10.16	6.34
5				-	-	-	-	-						-	-	-	-	-
6				8.76	10.72	3.84	10.16	6.34						8.76	10.72	3.84	10.16	6.34
7				-	-	-	-	-	10.0	7.1	1.7	.2	.2	10.0	7.1	1.7	.2	.2
8				-	-	-	-	-	4.9	3.5	.1	.1	.1	4.9	3.5	.1	.1	.1
9				-	-	-	-	-	11.2	7.9	1.4	.1	.1	11.2	7.9	1.4	.1	.1
10				4.32	5.29	1.9	5.02	3.13						4.32	5.29	1.9	5.02	3.13
11				4.98	6.1	2.18	5.78	3.61						4.98	6.1	2.18	5.78	3.61
12				4.98	6.1	2.18	5.78	3.61						4.98	6.1	2.18	5.78	3.61
13				4.32	5.29	1.9	5.02	3.13						4.32	5.29	1.9	5.02	3.13
14				4.32	5.29	1.9	5.02	3.13						4.32	5.29	1.9	5.02	3.13
15				4.98	6.1	2.18	5.78	3.61						4.98	6.1	2.18	5.78	3.61
16				4.98	6.1	2.18	5.78	3.61						4.98	6.1	2.18	5.78	3.61
17				4.32	5.29	1.9	5.02	3.13						4.32	5.29	1.9	5.02	3.13
18														-	-	-	-	-
19														-	-	-	-	-
20														-	-	-	-	-
21														-	-	-	-	-
22									.2	.2	1.7	7.1	10.0	.2	.2	1.7	7.1	10.0
23									.1	.1	.1	3.5	4.9	.1	.1	.1	3.5	4.9
24									.1	.1	1.4	7.9	11.2	.1	.1	1.4	7.9	11.2

TABLE 17. DE-A NODAL POWER DISTRIBUTION

0% Duty Cycle

NODE	INTERNAL DISSIPATION			SHUNT POWER + BATTERY + PSE					ABSORBED HEAT FLUX NOT ACCOUNTED FOR					TOTAL Q				
	CONSTANT	SCIENCE	PB	11.67°	45°	90°	-45°	-11.67°	11.67	45°	90°	-45°	-11.67°	11.67°	45°	90°	-45°	-11.67°
1	2.0	0	0	-		-	-	-						2.0	2.0	2.0	2.0	2.0
2	20.05	0	0	1.92	5	1.91	2.2	1.9						21.97	22.3	21.96	22.25	21.95
3				-		-	-	-						-	-	-	-	-
4				12.23	14.31	8.83	13.71	11.39						12.23	14.31	8.83	13.71	11.39
5				-	-	-	-	-						-	-	-	-	-
6				12.23	14.31	8.83	13.71	11.39						12.23	14.31	8.83	13.71	11.39
7				-	-	-	-	-	10.0	7.1	1.7	.2	.2	10.0	7.1	1.7	.2	.2
8				-	-	-	-	-	4.9	3.5	.1	.1	.1	4.9	3.5	.1	.1	.1
9				-	-	-	-	-	11.2	7.9	1.4	.1	.1	11.2	7.9	1.4	.1	.1
10				6.04	7.06	4.36	6.77	5.62						6.04	7.06	4.36	6.77	5.62
11				6.95	8.14	5.02	7.8	6.48						6.95	8.14	5.02	7.8	6.48
12				6.95	8.14	5.02	7.8	6.48						6.95	8.14	5.02	7.8	6.48
13				6.04	7.06	4.36	6.77	5.62						6.04	7.06	4.36	6.77	5.62
14				6.04	7.06	4.36	6.77	5.62						6.04	7.06	4.36	6.77	5.62
15				6.95	8.14	5.02	7.8	6.48						6.95	8.14	5.02	7.8	6.48
16				6.95	8.14	5.02	7.8	6.48						6.95	8.14	5.02	7.8	6.48
17				6.04	7.06	4.36	6.77	5.62						6.04	7.06	4.36	6.77	5.62
18				-	-	-	-	-						-	-	-	-	-
19				-	-	-	-	-						-	-	-	-	-
20				-	-	-	-	-						-	-	-	-	-
21				-	-	-	-	-						-	-	-	-	-
22				-	-	-	-	-	.2	.2	1.7	7.1	10.0	.2	.2	1.7	7.1	10.0
23				-	-	-	-	-	.1	.1	.1	3.5	4.9	.1	.1	.1	3.5	4.9
24				-	-	-	-	-	.1	.1	1.4	7.9	11.2	.1	.1	1.4	7.9	11.2

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 3.2.2-002-DN

Title: DE-B Simplified Thermal Model Description

Written by: P. Shang/O. Liu	Date: October 2, 1978
Approved by: C. Chhatpar	Date: 10 OCT 78
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

Letter	Description	Date	Author

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1.0 Summary

A 21-node steady state thermal model has been developed to evaluate the parametric performance of the DE-B spacecraft. The model computes orbit average temperatures as functions of sun angle and duty cycles of various heat dissipating components. Radiative couplings, whose values vary as a function of ATC positions, are automatically computed by the model.

2.0 Contents

Figure

1. DE-B Thermal Configuration

Table

1. Node Identification
2. External Sink Identification
3. External Sink Thermophysical Properties
4. Orbit Average External Sink Values
5-1 Spacecraft Internal Couplings
5-2 Spacecraft External Couplings
6-1 Nodal Power Distribution for Various Sun Angles: 50% Duty Cycle
6-2 Nodal Power Distribution for Various Sun Angles: 40% Duty Cycle
6-3 Nodal Power Distribution for Various Sun Angles: 30% Duty Cycle
6-4 Nodal Power Distribution for Various Sun Angles: 20% Duty Cycle
6-5 Nodal Power Distribution for Various Sun Angles: 10% Duty Cycle
6-6 Nodal Power Distribution for Various Sun Angles: 0% Duty Cycle
7-1 DE-B Thermal Power Configuration
7-2 DE-B Shunt Power Distribution
7-3 DE-B Battery and PSE Dissipation on Node 1

Appendix 1. Calculation of the Effective Aperture Properties for Nodes 15 and 16.

Appendix 2. Definition of Thermal Sink Value and Ris.

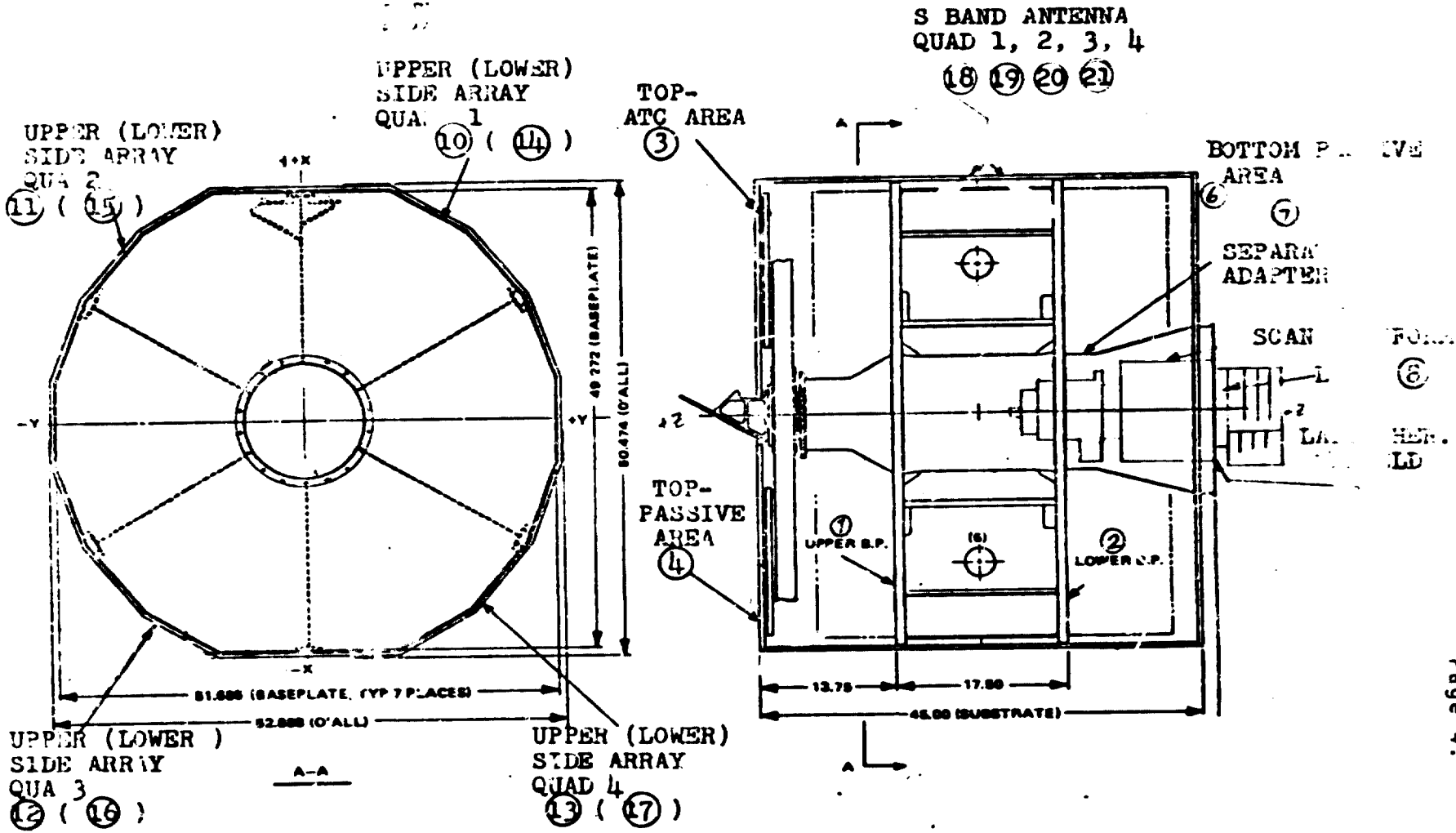


Figure 2 DE-B Thermal Configuration

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TABLE 1. NODE IDENTIFICATION

Node No.	Description
1	Upper Baseplate - Equipment Complex
2	Lower Baseplate - Equipment Complex
3	Top - ATC Area
4	Top - Passive Area
5	Bottom - Scan Platform
6	Bottom - Passive Area
7	Separation Adapter
8	LAPI
9	LAPI Thermal Shield
10	Upper Side Array - Quadrant 1
11	Upper Side Array - Quadrant 2
12	Upper Side Array - Quadrant 3
13	Upper Side Array - Quadrant 4
14	Lower Side Array - Quadrant 1
15	Lower Side Array - Quadrant 2
16	Lower Side Array - Quadrant 3
17	Lower Side Array - Quadrant 4
18	S-band Antenna - Quadrant 1
19	S-band Antenna - Quadrant 2
20	S-band Antenna - Quadrant 3
21	S-band Antenna - Quadrant 4

TABLE 2. EXTERNAL SINK IDENTIFICATION

Sink No.	Description
1	Spacecraft Top
2	Upper Side Array - Quadrant 1
3	Upper Side Array - Quadrant 2
4	Upper Side Array - Quadrant 3
5	Upper Side Array - Quadrant 4
6	Lower Side Array - Quadrant 1
7	Lower Side Array - Quadrant 2
8	Lower Side Array - Quadrant 3
9	Lower Side Array - Quadrant 4
10	Spacecraft Bottom
11	S-band Antenna - Quadrant 1
12	S-band Antenna - Quadrant 2
13	S-band Antenna - Quadrant 3
14	S-band Antenna - Quadrant 4
15	Upper Baseplate - Experiment Ports
16	Lower Baseplate - Experiment Ports
17	Space

Table 3. External Sink Thermophysical Properties

Sink No.	Solar Absorptivity α		$\alpha_{BOL}/\alpha_{EOL}$	IR Emissivity
	BOL	EOL		
1	.725	.763	1.052	.81
2	.660	.717	1.086	.74
3	.660	.717	1.086	.74
4	.660	.717	1.086	.74
5	.660	.717	1.086	.74
6	.631	.686	1.087	.757
7	.631	.686	1.087	.757
8	.631	.686	1.087	.757
9	.631	.686	1.087	.757
10	.725	.763	1.052	.81
11	.305	.455	1.492	.274
12	.305	.455	1.492	.274
13	.305	.455	1.492	.274
14	.305	.455	1.492	.274
15	.649	.693	1.068	.474
16	.25	.35	1.4	.560
17	1.0	1.0	1.0	1.0

Properties of nodes 1 through 14 are obtained from Electrodynamics Explorers Thermal Model Description, EE-DN-TH-1, dated 7 Sept. 1976. The properties of nodes 15 and 16 are taken from the effective Aperture properties, calculated as per Appendix 1.

TABLE 4. ORBIT-AVERAGE EXTERNAL SINK VALUES FOR DE-B SPACECRAFT

Sink No.	Sink Equivalent Black-Body Radiation (Watts/Sq-In)					
	BOL - 1 RPO Apogee = 1200 km Perigee = 275 km			EOL - 1 RPO Apogee = 1200 km Perigee = 275 km		
	Orbit Sun Angle			Orbit Sun Angle		
	0	30	90	0	30	90
1	0.037	0.045	0.063	0.048	0.047	0.079
2	0.091	0.256	0.234	0.104	0.278	0.245
3	0.088	0.252	0.231	0.101	0.274	0.241
4	0.003	0.125	0.239	0.007	0.136	0.273
5	0.007	0.128	0.242	0.011	0.139	0.276
6	0.091	0.245	0.225	0.104	0.266	0.236
7	0.088	0.242	0.221	0.101	0.263	0.232
8	0.003	0.117	0.223	0.007	0.127	0.255
9	0.007	0.120	0.227	0.011	0.130	0.259
10	0.856	0.754	0.063	0.909	0.793	0.079
11	0.097	0.302	0.275	0.110	0.451	0.351
12	0.088	0.293	0.266	0.101	0.437	0.341
13	0.003	0.155	0.297	0.007	0.231	0.462
14	0.012	0.164	0.307	0.016	0.245	0.471
15	0.045	0.261	0.358	0.043	0.279	0.360
16	0.021	0.101	0.091	0.053	0.141	0.250
17	0.000	0.000	0.000	0.003	0.000	0.000

TABLE 5.1 SPACECRAFT INTERNAL COUPLINGS

INTERNAL COUPLING							
FROM	TO	RADIATIVE COUPLING (IN^2)	CONDUCTIVE COUPLING (W/°C)	FROM	TO	RADIATIVE COUPLING (IN^2)	CONDUCTIVE COUPLING (W/°C)
1	2	787.0	2.5	2	21	0.4	
1	3	59.0		3	4		0.65
1	4	44.9		3	10	4.175	
1	10	132.5	0.028	3	11	4.175	
1	11	132.5	0.028	3	12	4.175	
1	12	132.5	0.028	3	13	4.175	
1	13	132.5	0.028	4	10	1.5	0.1
1	14	7.7		4	11	1.5	0.1
1	15	7.65		4	12	1.5	0.1
1	16	7.65		4	13	1.5	0.1
1	17	7.65		5	6		0.65
1	18	3.6		5	7	236.0	1.041
1	19	3.6		5	8	184.32	7.6
1	20	3.6		6	7	3.9	0.1
1	21	3.6		6	8	29.81	
2	6	44.1		6	14	1.5	0.5
2	7		1.260	6	15	1.5	0.5
2	10	0.9		6	16	1.5	0.5
2	11	0.9		6	17	1.5	0.5
2	12	0.9		7	8	370.0	0.2
2	13	0.9		7	9	6.2	
2	14	75.0	0.024	7	14	0.2	
2	15	75.0	0.024	7	15	1.5	
2	16	75.0	0.024	7	16	0.2	
2	17	75.0	0.024	7	17	0.2	
2	18	0.4		8	9		0.05
2	19	0.4		10	11		0.04
2	20	0.4		10	13		0.04

TABLE 5.1 SPACECRAFT INTERNAL COUPLINGS (continued)

INTERNAL COUPLING							
FROM	TO	RADIATIVE COUPLING (IN^2)	CONDUCTIVE COUPLING (W/°C)	FROM	TO	RADIATIVE COUPLING (IN^2)	CONDUCTIVE COUPLING (W/°C)
10	18		0.09				
11	12		0.04				
11	19		0.09				
12	13		0.04				
12	20		0.09				
13	21		0.09				
14	15		0.04				
14	17		0.04				
14	18		0.09				
15	16		0.04				
15	19		0.09				
16	17		0.04				
16	20		0.09				
17	21		0.09				
18	19		0.027				
18	21		0.027				
19	20		0.027				
20	21		0.027				

TABLE 5-2. SPACECRAFT EXTERNAL COUPLINGS

FROM NODE	TO SINK	RADIATIVE COUPLING (IN^2)	FROM NODE	TO SINK	RADIATIVE COUPLINGS (IN^2)
1	15	8.234	11	3	662.0
1	17	(1)	12	4	662.0
2	16	0.01	13	5	662.0
3	1	686.48	14	6	544.0
4	1	537.6	15	7	544.0
6	10	874.8	16	8	544.0
7	17	9.5	17	9	544.0
8	17	252.0	18	11	33.5
9	17	10.0	19	12	33.5
10	2	662.0	20	13	33.5
			21	14	33.5

(1) Value variable, depending on the position of ATC position.

TABLE 6-1. NODAL POWER DISTRIBUTION FOR VARIOUS SUN ANGLES: 50% DUTY CYCLE

NODE NO.	INTERNAL DISSIPATION			SHUNT PWS + BAT + P.S.E.			ABSORBED HEAT FLUX NOT ACCOUNTED FOR			TOTAL Q		
	CON-STANT	SCIENCE	PLAY-BACK	SUN ANG 0°	30°	90°	0°	30°	90°	0°	30°	90°
1	31.35	9.25	1.37	14.2	13.42	7.42	-	-	-	56.17	55.39	49.39
2	2.38	23.55	1.31	-	-	-	-	-	-	27.24	27.24	27.24
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	1.824	3.326	.331	-	-	-	1.824	3.326	.331
5	-	2.64	-	-	-	-	-	-	-	2.64	2.64	2.64
6	-	-	-	1.824	3.326	.331	-	-	-	1.824	3.326	.331
7	-	-	-	-	-	-	10.0	8.66	1.7	10.0	8.66	1.7
8	-	7.2	-	-	-	-	9.37	29.8	27.07	16.57	37.0	34.27
9	-	-	-	-	-	-	11.2	9.7	1.4	11.2	9.7	1.4
10	-	-	-	.9	1.642	.164	-	-	-	.9	1.642	.642
11	-	-	-	1.04	1.892	.188	-	-	-	1.04	1.892	.188
12	-	-	-	1.04	1.892	.188	-	-	-	1.04	1.892	.188
13	-	-	-	.9	1.642	.164	-	-	-	.9	1.642	.164
14	-	-	-	.9	1.642	.164	-	-	-	.9	1.642	.164
15	-	-	-	1.04	1.892	.188	-	-	-	1.04	1.892	.188
16	-	-	-	1.04	1.892	.188	-	-	-	1.04	1.892	.188
17	-	-	-	.9	1.642	.164	-	-	-	.9	1.642	.164
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-

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TABLE 6-2. NODAL POWER DISTRIBUTION FOR VARIOUS SUN ANGLES: 40% DUTY CYCLE

NODE NO.	INTERNAL DISSIPATION			SHUNT PW+BAT+P.S.E.			ABSORBED HEAT FLUX NOT ACCOUNTED FOR			TOTAL Q		
	CON-STANT	SCIENCE	PLAY-BACK	0°	30°	90°	0°	30°	90°	0°	30°	90°
1	31.345	7.4	1.1	11.74	11.14	7.42	-	-	-	51.585	50.985	47.265
2	2.375	19.16	1.09	-	-	-	-	-	-	22.625	22.238	27.625
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	1.824	3.326	.331	-	-	-	1.824	3.326	.331
5	-	2.64	-	-	-	-	-	-	-	2.64	2.64	2.64
6	-	-	-	1.824	3.326	.331	-	-	-	1.824	3.326	.331
7	-	-	-	-	-	-	10.0	8.66	1.7	10.0	8.66	1.7
8	-	7.2	-	-	-	-	9.37	29.8	27.07	16.57	37.0	34.27
9	-	-	-	-	-	-	11.2	9.7	1.4	11.2	9.7	1.4
10	-	-	-	.9	1.642	.164	-	-	-	.9	1.642	.164
11	-	-	-	1.04	1.892	.188	-	-	-	1.04	1.892	.188
12	-	-	-	1.04	1.892	.188	-	-	-	1.04	1.892	.188
13	-	-	-	.9	1.642	.164	-	-	-	.9	1.642	.164
14	-	-	-	.9	1.642	.164	-	-	-	.9	1.642	.164
15	-	-	-	1.04	1.892	.188	-	-	-	1.04	1.892	.188
16	-	-	-	1.04	1.892	.188	-	-	-	1.04	1.892	.188
17	-	-	-	.9	1.642	.164	-	-	-	.9	1.642	.164
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 6-3. NODAL POWER DISTRIBUTION FOR VARIOUS SUN ANGLES: 30% DUTY CYCLE

NODE NO.	INTERNAL DISSIPATION			SHUNT PW + BAT + PSF			ABSORBED HEAT FLUX NOT ACCOUNTED FOR			TOTAL Q		
	CON-STANT	SCIENCE	PLAY-BACK	0°	30°	90°	0°	30°	90°	0°	30°	90°
1	31.345	5.55	.821	9.28	8.86	7.42	-	-	-	46.996	46.576	45.136
2	2.375	14.37	.808	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	4.15	5.65	.331	-	-	-	4.15	5.65	.331
5	-	1.98	-	-	-	-	-	-	-	1.98	1.98	1.98
6	-	-	-	4.15	5.65	.331	-	-	-	4.15	5.65	.331
7	-	-	-	-	-	-	10.0	8.66	1.7	10.0	8.66	1.7
8	-	5.4	-	-	-	-	9.37	29.8	27.07	14.77	35.2	32.47
9	-	-	-	-	-	-	11.2	9.7	1.4	11.2	9.7	1.4
10	-	-	-	2.05	2.79	.164	-	-	-	2.05	2.79	.164
11	-	-	-	2.36	3.21	.188	-	-	-	2.36	3.21	.188
12	-	-	-	2.36	3.21	.188	-	-	-	2.36	3.21	.188
13	-	-	-	2.05	2.79	.164	-	-	-	2.05	2.79	.164
14	-	-	-	2.05	2.79	.164	-	-	-	2.05	2.79	.164
15	-	-	-	2.36	3.21	.188	-	-	-	2.36	3.21	.188
16	-	-	-	2.36	3.21	.188	-	-	-	6.4	5.96	1.729
17	-	-	-	.05	2.79	.164	-	-	-	2.05	2.79	.164
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 6-4. NODAL POWER DISTRIBUTION FOR VARIOUS SUN ANGLES: 20% DUTY CYCLE

NODE NO.	INTERNAL DISSIPATION			SHUNT PW + BAT + PSE			ABSORBED HEAT FLUX NOT ACCOUNTED FOR			TOTAL Q		
	CON-STANT	SCIENCE	PLAY-BACK	0°	30°	90°	0°	30°	90°	0°	30°	90°
1	31.345	3.7	.55	6.82	6.58	7.42	-	-	-	42.415	42.175	43.015
2	2.375	9.58	.545	-	-	-	-	-	-	12.5	12.5	12.5
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	6.53	8.03	.331	-	-	-	6.53	8.03	.331
5	-	1.32	-	-	-	-	-	-	-	1.32	1.32	1.32
6	-	-	-	6.53	8.03	.331	-	-	-	6.53	8.03	.331
7	-	-	-		-	-	10.0	8.66	1.7	10.0	8.66	1.7
8	-	3.6	-	-	-	-	9.37	29.8	27.07	12.97	33.4	30.67
9	-	-	-	-	-	-	11.2	9.7	1.4	11.2	9.7	1.4
10	-	-	-	3.22	3.97	.164	-	-	-	3.22	3.97	.164
11	-	-	-	3.71	4.57	.188	-	-	-	3.71	4.57	.188
12	-	-	-	3.71	4.57	.188	-	-	-	3.71	4.57	.188
13	-	-	-	3.22	3.97	.164	-	-	-	3.22	3.97	.164
14	-	-	-	3.22	3.97	.164	-	-	-	3.22	3.97	.164
15	-	-	-	3.71	4.57	.188	-	-	-	3.71	4.57	.188
16	-	-	-	3.71	4.57	.188	-	-	-	3.71	4.57	.188
17	-	-	-	3.22	3.97	.164	-	-	-	3.22	3.97	.164
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 6-5. NODAL POWER DISTRIBUTION FOR VARIOUS SUN ANGLES: 10% DUTY CYCLE

NODE NO.	INTERNAL DISSIPATION			SHUT + BAT + PSE			ABSORBED HEAT FLUX NOT ACCOUNTED FOR			TOTAL Q		
	CON-STANT	SCIENCE	PLAY-BACK	18°	30°	90°	18°	30°	90°	18°	30°	90°
1	31.345	1.85	.274	4.35	4.30	6.48	-	-	-	37.819	37.769	39.949
2	2.375	4.79	.273	-	-	-	-	-	-	7.398	7.398	7.398
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	8.98	10.48	.8	-	-	-	8.98	10.48	.8
5	-	.66	-	-	-	-	-	-	-	.66	.66	.66
6	-	-	-	8.98	10.48	.8	-	-	-	8.98	10.48	.8
7	-	-	-	-	-	-	10.0	8.66	1.7	11.25	12.8	3.04
8	-	1.8	-	-	-	-	9.37	29.8	27.07	10.0	8.66	1.7
9	-	-	-	-	-	-	11.2	9.7	1.4	11.2	9.7	1.4
10	-	-	-	4.44	5.18	.395	-	-	-	4.44	5.18	.395
11	-	-	-	5.11	5.96	.455	-	-	-	5.11	5.96	.455
12	-	-	-	5.11	5.96	.455	-	-	-	5.11	5.96	.455
13	-	-	-	4.44	5.18	.395	-	-	-	4.44	5.18	.395
14	-	-	-	4.44	5.18	.395	-	-	-	4.44	5.18	.395
15	-	-	-	5.11	5.96	.455	-	-	-	5.11	5.96	.455
16	-	-	-	5.11	5.96	.455	-	-	-	5.11	5.96	.455
17	-	-	-	4.44	5.18	.395	-	-	-	4.44	5.18	.395
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 6-6 NODAL POWER DISTRIBUTION FOR VARIOUS SUN ANGLES: 0% DUTY CYCLE

DUTY CYCLE/ NODE NO.	INTERNAL DISSIPATION			SHUNT PW + BAT + PSE			ABSORBED HEAT FLUX NOT ACCOUNTED FOR			TOTAL Q		
	CON-STANT	SCIENCE	PLAY-BACK	18°	30°	90°	18°	30°	90°	18°	30°	90°
0% 1	31.345	-	-	2.13	2.9	3.74	-	-	-	33.475	34.245	35.085
2	2.375	-	-	-	-	-	-	-	-	2.375	2.375	2.375
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	11.25	12.8	3.04	-	-	-	11.25	12.8	3.04
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	11.25	12.8	3.04	-	-	-	11.25	12.8	3.04
7	-	-	-	-	-	-	10.0	8.66	1.7	10.0	8.66	1.7
8	-	-	-	-	-	-	9.37	29.8	27.07	9.37	29.8	27.07
9	-	-	-	-	-	-	11.2	9.7	1.4	11.2	9.7	1.4
10	-	-	-	5.56	5.18	1.501	-	-	-	5.56	5.18	1.501
11	-	-	-	6.4	5.18	1.501	-	-	-	6.4	5.18	1.501
12	-	-	-	6.4	5.18	1.501	-	-	-	6.4	5.18	1.501
13	-	-	-	5.56	5.18	1.501	-	-	-	5.56	5.18	1.501
14	-	-	-	5.56	5.18	1.501	-	-	-	5.56	5.18	1.501
15	-	-	-	6.4	5.96	1.729	-	-	-	6.4	5.96	1.729
16	-	-	-	6.4	5.96	1.729	-	-	-	6.4	5.96	1.729
17	-	-	-	5.56	5.18	1.501	-	-	-	5.56	5.18	1.501
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 7-1. DE-B THERMAL POWER CONFIGURATION

Instrument/Box	Internal Power Distribution (watts)											
	Continuous Load	Science	Playback	Duty Cycle								
				at 45%		at 33.75%		at 22.5%		at 11.25%		at 0%	
				SCI (40%)	PB (5%)	SCI (30%)	PB (3.75%)	SCI (20%)	PB (2.5%)	SCI (10%)	PB (1.25%)	SCI (0%)	PB (0%)
Upper Baseplate													
FEA		5.5											
FPI		8.0											
DM		5.0											
PTX-B	10.1		21.9										
[illegible]	2.24												
[illegible]	3.5												
[illegible]	6.63												
[illegible] Torquer	0.375												
[illegible]CDU	2.5												
[illegible]	1.0												
[illegible]	3.0												
[illegible]mal	2.0												
SUBTOTAL	31.345	18.5	21.9	7.40	1.095	5.55	0.821	3.7	0.548	1.85	0.274	0	0
Lower Baseplate													
MAG		3.5											
[illegible]		14.0											
[illegible]MG		3.0											
[illegible]PE		4.0											
[illegible]AC		12.0											
TR		10.6	21.0										
½ Mag Torquer	0.375												
Thermal	2.0												
SUBTOTAL	2.375	47.1	21.0	18.84	1.05	14.13	0.788	9.42	0.525	4.71	0.263	0	0
TOTAL	33.72	65.6	42.9										

SCI = Science
PB = Playback

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TABLE 7-2. DE-B SHUNT POWER DISTRIBUTION*

*FROM POWER RUN #127-#131

DUTY CYCLE		50%			40%			30%			20%			10%			0%		
SUN ANGLE		0°	30°	90°	0°	30°	90°	0°	30°	90°	0°	30°	90°	0°	30°	90°	0°	30°	90°
NODE	TOTAL FRAC	11.4	20.79	2.07	11.4	20.79	2.07	25.91	35.29	2.07	40.81	50.2	2.07	56.15	65.53	5.0	70.33	80.0	10.0
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	.16	1.824	3.326	.331	1.824	3.326	.331	4.15	5.65	.331	6.53	8.03	.331	8.98	10.48	.8	11.25	12.8	3.04
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	.16	1.824	3.326	.331	1.824	3.326	.331	4.15	5.65	.331	6.53	8.03	.331	8.98	10.48	.8	11.25	12.8	3.04
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	.079	.9	1.642	.164	.9	1.642	.164	2.05	2.79	.164	3.22	3.99	.164	4.44	5.18	.395	5.56	5.18	1.501
11	.091	1.04	1.892	.188	1.04	1.892	.188	2.36	3.21	.188	3.71	4.57	.188	5.11	5.96	.455	6.4	5.96	1.729
12	.091	1.04	1.892	.188	1.04	1.892	.188	2.36	3.21	.188	3.71	4.57	.188	5.11	5.96	.455	6.4	5.96	1.729
13	.079	.9	1.642	.164	.9	1.642	.164	2.05	2.79	.164	3.22	3.97	.164	4.44	5.18	.395	5.56	5.18	1.501
14	.079	.9	1.642	.164	.9	1.642	.164	2.05	2.79	.164	3.22	3.97	.164	4.44	5.18	.395	5.56	5.18	1.501
15	.091	1.04	1.892	.188	1.04	1.892	.188	2.36	3.21	.188	3.71	4.57	.188	5.11	5.96	.455	6.4	5.96	1.729
16	.091	.091	1.892	.188	1.04	1.892	.188	2.36	3.21	.188	3.71	4.57	.188	5.11	5.96	.455	6.4	5.96	1.729
17	.079	.079	1.642	.164	.9	1.642	.164	2.05	2.79	.164	3.22	3.97	.164	4.44	5.18	.395	5.56	5.18	1.501
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 7-3

DE-B BATTERY AND PSE POWER DISSIPATION ON NODE 1

DUTY CYCLE	SUN ANGLE	BATTERY DISSIPATION	POWER S.E.	TOTAL POWER ON NODE 1
50%	0°	4.40	9.80	14.2
	30°	3.84	9.58	13.42
	90°	3.37	4.05	7.42
40%	0°	3.33	8.41	11.74
	30°	2.88	8.26	11.14
	90°	3.37	4.05	7.42
30%	0°	2.50	6.78	9.28
	30°	2.16	6.7	8.86
	90°	3.37	4.05	7.42
20%	0°	1.67	5.15	6.82
	30°	1.44	5.14	6.58
	90°	3.37	4.05	7.42
10%	0°	.83	3.52	4.35
	30°	.72	3.58	4.3
	90°	3.0	3.48	6.48
0%	0°	.08	2.05	2.13
	30°	.08	2.1	2.18
	90°	1.91	1.83	3.74

APPENDIX 1. CALCULATION OF EFFECTIVE APERTURE PROPERTIES FOR NODE 15 AND 16

COMPONENTS	APERTURE AREA (A) (in^2)	ABSORPTIVITY (α)		ABSORPTIVITY*AREA $\alpha*A$		EMISSIVITY ϵ	$\epsilon*A$
		BOL	EOL	BOL	EOL		
Upper Baseplate Node 15							
RPA	2 x 1.95	0.25	0.35	0.975	1.365	0.055	0.215
FFI	4 x 2.5	0.96	0.96	9.6	9.6	0.8	8.
IDM	2 x 1.95	0.25	0.35	0.975	1.365	0.055	0.215
TOTAL	17.8			11.55	12.33		8.43
Effective Prop. For Node 15		0.649	0.693			0.473	
Lower Base P. for Node 16							
NACS	0.012	0.25	0.35	0.003	0.0042	0.56	0.00672
WAT	0.0123	0.25	0.35	0.0031	0.0043	0.56	0.00689
TOTAL	0.0243			0.0061	0.0085		0.0134
Effective Prop. For Node 16		0.25	0.35			0.56	

APPENDIX 2. Definition of Thermal Sink Value and RIS

Absorbed external flux to a node i (watt/in^2)

= Solar flux + Albedo flux + Earth IR flux

= $A_i \alpha_i$ [solar intensity] + $A_i \alpha_i$ [Albedo intensity] + $A_i \varepsilon_i$ [Earth IR]

= $A_i \varepsilon_i \left[\frac{\alpha_i}{\varepsilon_i}\right.$(solar + albedo) + Earth IR]

Define $R_{is} = A_i \varepsilon_i$ (see Table 5-2), and

$$I_i = \frac{\alpha_i}{\varepsilon_i}\left[\text{solar + albedo}\right] + \text{Earth IR (See Table 4)}$$

then, for a flat surface of a convex body, the absorbed external flux of node i is (R_{is}) (I_i).

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 3.2.2-003-DN

Title

DE-A Baseline Thermal Model Performance and Analysis

Written by: C. Chhatpar	Date 9/29/78
Approved by: W. V. Fuldner	Date 10/2/78
This DN supplements (S), replaces (R) DN Nos. (S) 3.2.2-001-DN ( )	

REVISIONS

Letter	Description	Date	Author

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SUMMARY

The DE-A mission imposes severe restraints on the spacecraft thermal design, since it will remain in a fixed orientation relative to the roll and yaw axes throughout the mission. This gives a possible sun angle range of 0° to 180° for the spacecraft. Since the power subsystem cannot supply required amount of solar array power at 0° sun angle for a minimum required duty cycle of the science payload, the minimum sun angle has been restricted to $\pm 18^{o}$. Nevertheless, the solar flux impinges on all sides of the spacecraft and the thermal design has to be able to maintain thermal balance during all sun angles.

A baseline configuration consists of active thermal control (ATC) louvers on the top and bottom surfaces of the spacecraft with no cutouts in the end panels for the ATC's. This configuration is the same as described in the DE Technical Proposal No. 102658-C, June 30, 1978.

DESIGN CONFIGURATION

The principal features of the DE-A thermal system design are illustrated in Figure 1. Simplified thermal model data for the DE-A spacecraft is described in DE design note 3.2.2-001-DN.

The upper-and-lower end substrates (arrays) serve as the principal sinks for the internal power dissipations, as one of the two end arrays will always be in the anti-sun side of the spacecraft. The radiation couplings from the baseplate equipment to these principal radiating surfaces are varied by a set of six 14.5-inch diameter, 4-double-blade pinwheel type, active-thermal-control louvers in each array. Radiation coupling from upper baseplate to upper ATC is varied from 69.0 in^2 (louvers fully closed) to 409.0 in^2 (louvers fully open) and likewise for the radiation coupling from lower baseplate to lower ATC. The design is symmetrical with respect to upper and lower compartments, and any differences in performance can be attributed to variations in power distribution, aperture areas, and equipment duty cycles unique to the particular baseplates.

The thermal program automatically computes variable radiation couplings of internal nodes to active thermal louver area as a function of active-thermal-control louver positions (fully open to fully closed) which are dependent upon the baseplate temperatures. Since there are no cutouts in the ends of both hats, the end solar arrays act as cold sinks for the ATC's, with the end solar arrays looking into space. This DE-A configuration is obviously less efficient than that of the DE-B spacecraft where the top-hat end array has cutouts through which the internal equipment views space as a function of louver position.

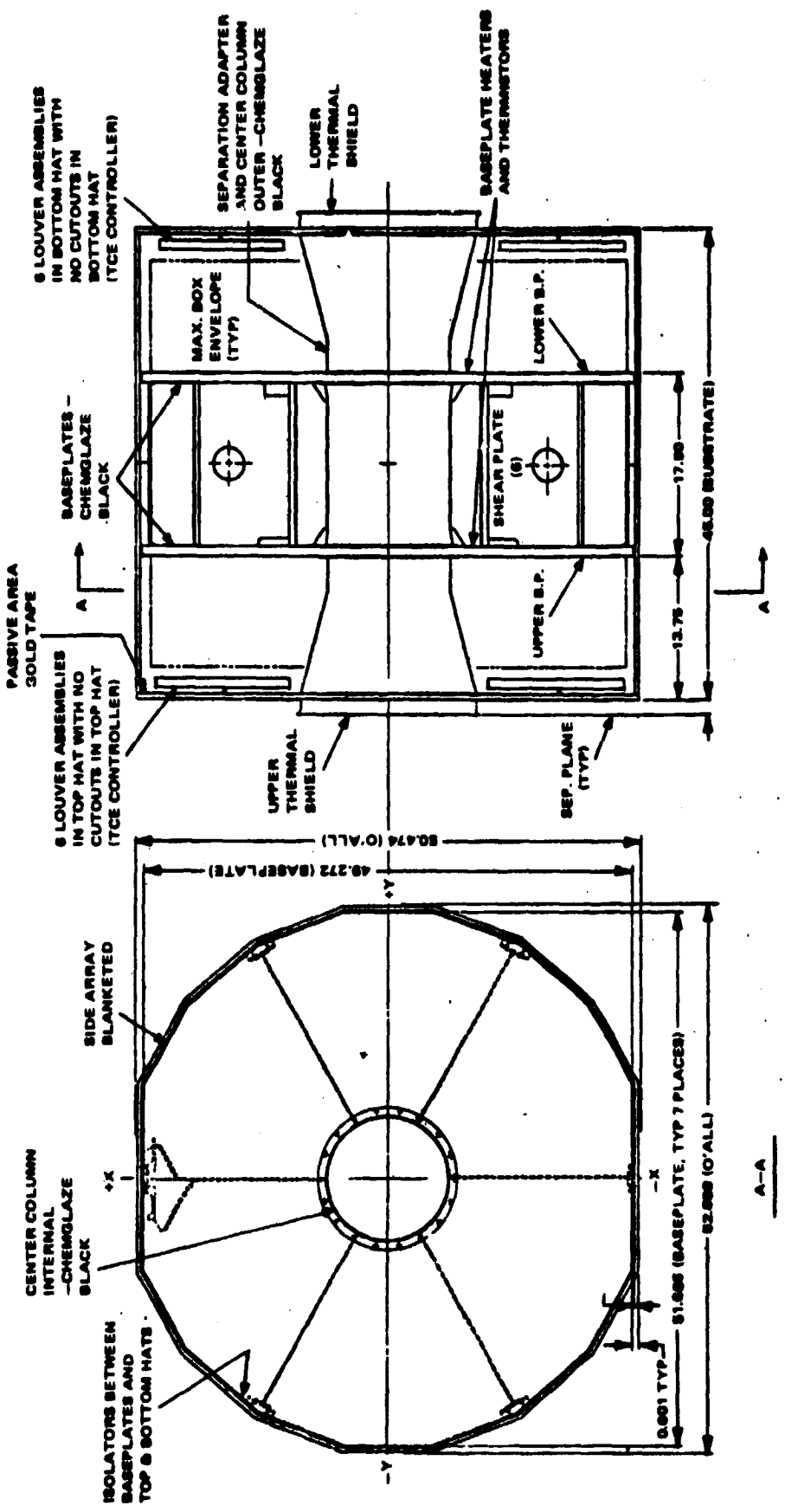


Figure 1: DE-A Thermal Configuration

All data for the simplified thermal model for this configuration is contained in 3.2.2-001-DN which also describes variable parameters that depend on design configuration. Table 1 provides data of variable parameters for this configuration. Appendix A provides computer printout of temperature prediction for a representative duty cycle.

3. THERMAL PERFORMANCE

The orbit-average temperatures of upper and lower baseplates as a function of instrument-payload duty cycles, sun angles, and BOL versus EOL variations in thermal properties are plotted in Figures 2 and 3. Data for the 0-percent and 69.75-percent duty cycles are replotted in Figures 4 and 5. Table 2 extracts the data from these two figures. The 0-degree sun angle, 0-percent duty cycle is a realistic flight case (initial maneuver, injection to prior-to-final orbital configuration) which drives the upper baseplate to a worst-case cold temperature of -16°C if no heaters are present. The dual TCE control will provide for the heater power when the thermistor senses the baseplate temperature below 1°C. Figures 2 and 3 show that the spacecraft-temperature sensitivity to power dissipation is about 0.35°C/watt. Therefore, about 46.0 watts of heater power will be required to maintain the baseplate at 0°C, with 0-percent duty cycle of the Science payload and with the spacecraft at 0-degree sun angle. This heater power, combined with the continuous load of 18.0 watts (22-4 watt thermal), results in a required power of 64.0 watts. Since the present DE-A end solar panel can provide only 52.0 watts, only 34.0 watts of power is available for the ATCE heater. The resulting upper-baseplate temperature of -4°C is considered acceptable baseline design for the short duration phase when all the Science payload is off and non-operational temperature specification limits would be applicable. However, since batteries and tape recorders have narrower specification limits, they will require special attention. The baseplate heaters may be placed strategically near the batteries to provide them with better thermal control. Similar arrangements may be provided for the tape recorders, or wider temperature specifications may be suggested for them. An alternate approach will be to increase the end-solar-array available power by the addition of cells to accommodate the heater requirements.

At the high-temperature end, nominal Science-payload duty cycle of 62-percent (69.75-percent duty cycle of Science and playback) and spacecraft in orbital configuration, a maximum EOL orbit-average steady-state temperature of 27.5°C is obtained on the lower baseplate (see Table 2). This steady-state temperature combined with the thermal transients ($\pm$2°C), gradients across the baseplates (of the order of $\pm$2°C) as well as the uncertainty factor of $\pm$3°C applied to the analytical predicts, require that the upper temperature limit of the baseplates (component mounting interfaces) be set at +35°C. Again for the 62-percent duty cycle of Science payload, the BOL minimum temperature of the lower baseplate is shown to be 5.5°C for the 90-degree sun angle.

TABLE 1. VARIABLE PARAMETRIC VALUES FOR THIS CONFIGURATION

FROM NODE	TO NODE	INTERNAL RADIATION COUPLING (IN^2) LOUVERS FULLY CLOSED	INTERNAL RADIATION COUPLING (IN^2) LOUVERS FULLY OPEN	COMMENTS (See Note 1)
1	3	69.0	408.97	Variable values for γ <90°; fully closed lvrs values for γ >90°.
1	22	646.5	536.5	Variable values for γ <90°; fully closed lvrs values for γ >90°.
2	5	69.0	408.97	Variable values for γ >90°; fully closed lvrs values for γ <90°.
2	7	646.5	536.5	Variable values for γ >90°; fully closed lvrs values for γ <90°.
3	10	0.85	5.0	Variable values for γ <90°; fully closed lvrs values for γ >90°.
3	11	.85	5.0	Variable values for γ <90°; fully closed lvrs values for γ >90°.
3	12	.85	5.0	Variable values for γ <90°; fully closed lvrs values for γ >90°.
3	13	.85	5.0	Variable values for γ <90°; fully closed lvrs values for γ >90°.
3	22	18.4	107.1	Variable values for γ <90°; fully closed lvrs values for γ >90°.
5	7	18.4	107.1	Variable values for γ >90°; fully closed lvrs values for γ <90°.
5	14	.85	5.0	Variable values for γ >90°; fully closed lvrs values for γ <90°.
5	15	.85	5.0	Variable values for γ >90°; fully closed lvrs values for γ <90°.
5	16	.85	5.0	Variable values for γ >90°; fully closed lvrs values for γ <90°.
5	17	.85	5.0	Variable values for γ >90°; fully closed lvrs values for γ <90°.
NODE	SINK	EXTERNAL RADIATION COUPLING (IN^2)		
1	17	0.0	0.0	Variable values for γ <90°; fully closed lvrs values for γ >90°.
2	17	0.0	0.0	Variable values for γ >90°; fully closed lvrs values for γ <90°.
		CONDUCTIVE COUPLING (WATTS/°C)		
1	2	1.25		This value is same as used in EE analysis.

NOTE 1. Fully closed louvers values are applicable for baseplate temperatures below 12°C; fully open louver values for temperature above 13°C. Program computes proportional values between 12°C and 13°C.

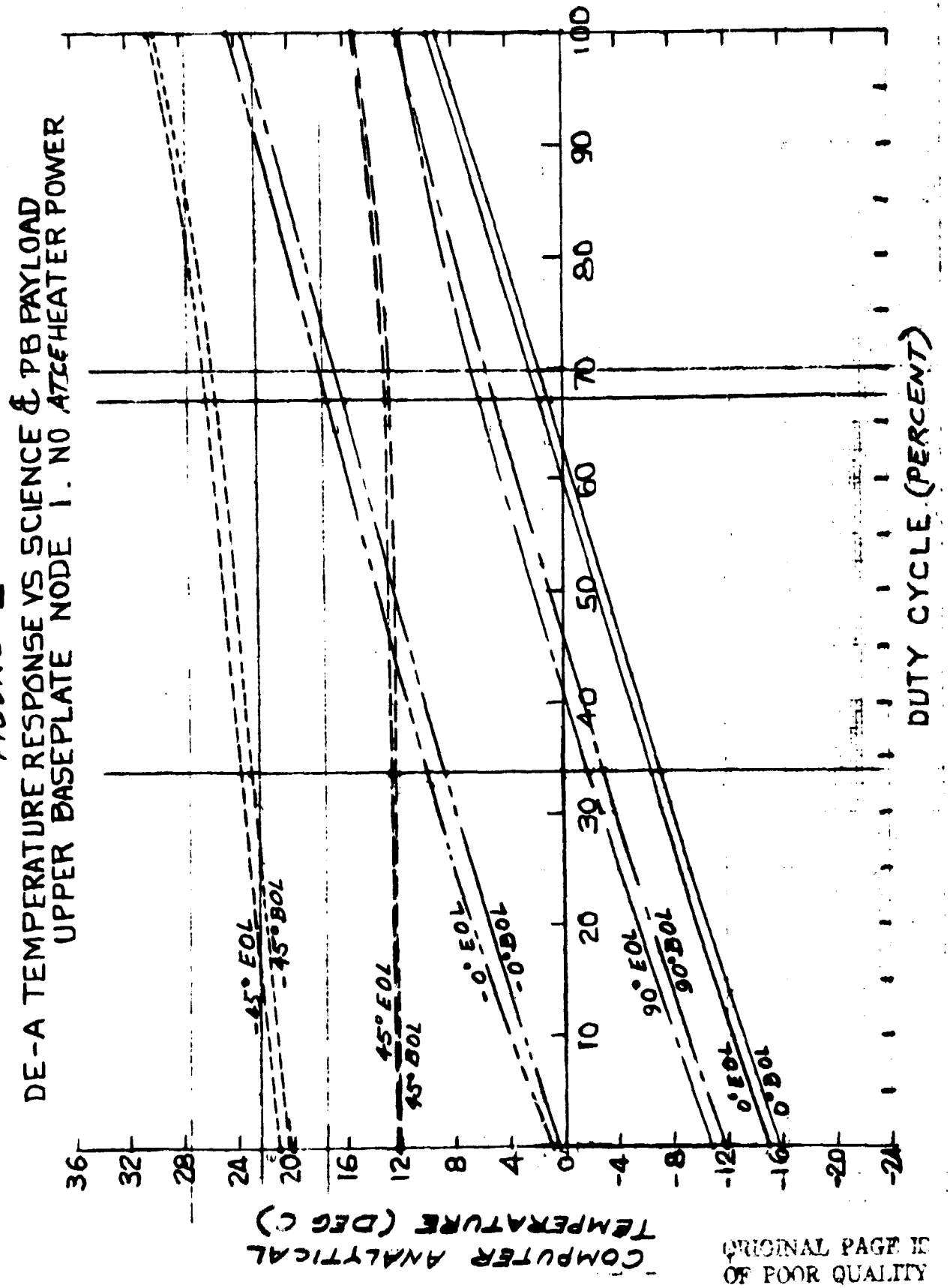


FIGURE 2

ORIGINAL PAGE IS
OF POOR QUALITY

FIGURE 3

DE-A TEMPERATURE RESPONSE VS SCIENCE & PB PAYLOAD
LOWER BASEPLATE NODE 2 NOATCE HEATER POWER

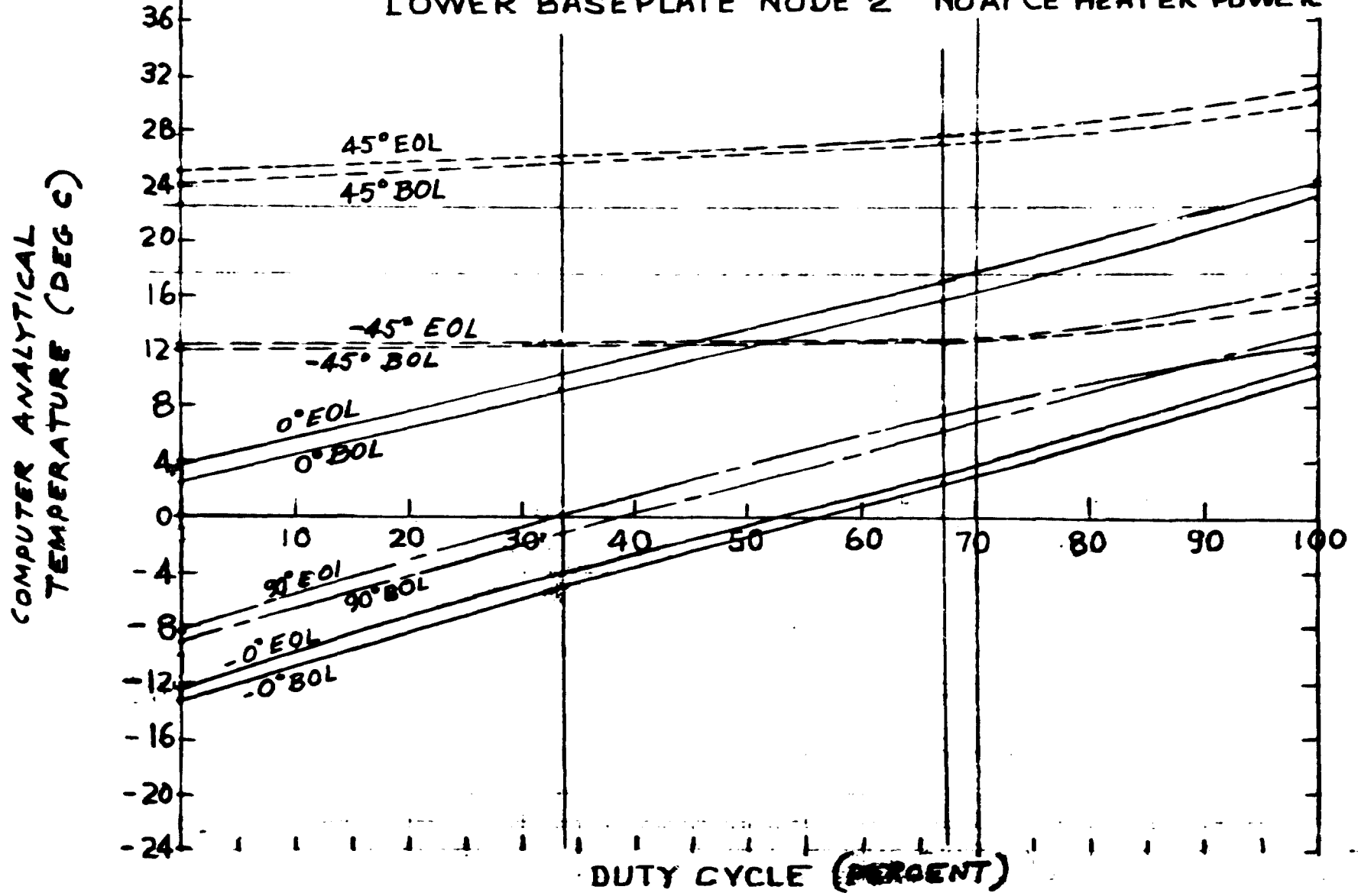


FIGURE 4

DE-A UPPER AND LOWER BASEPLATE TEMPERATURES, BOL VS EOL
0% DUTY CYCLE (NO ATCE HEATER POWER)

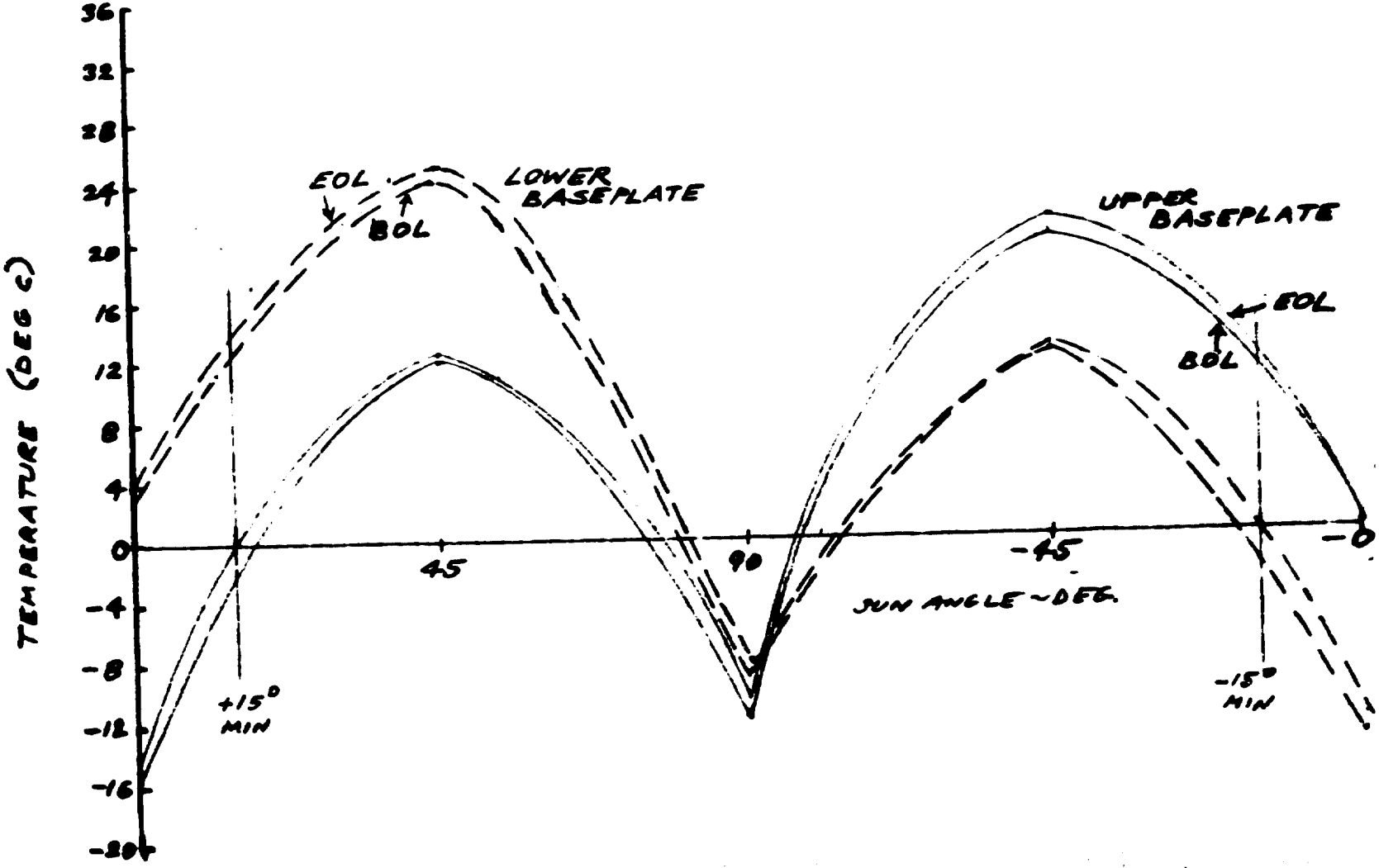


FIGURE 5
DE-A UPPER AND LOWER BASEPLATE TEMPERATURES, BOL VS EOL
69.75% DUTY CYCLE (SCIENCE AND PLAYBACK)

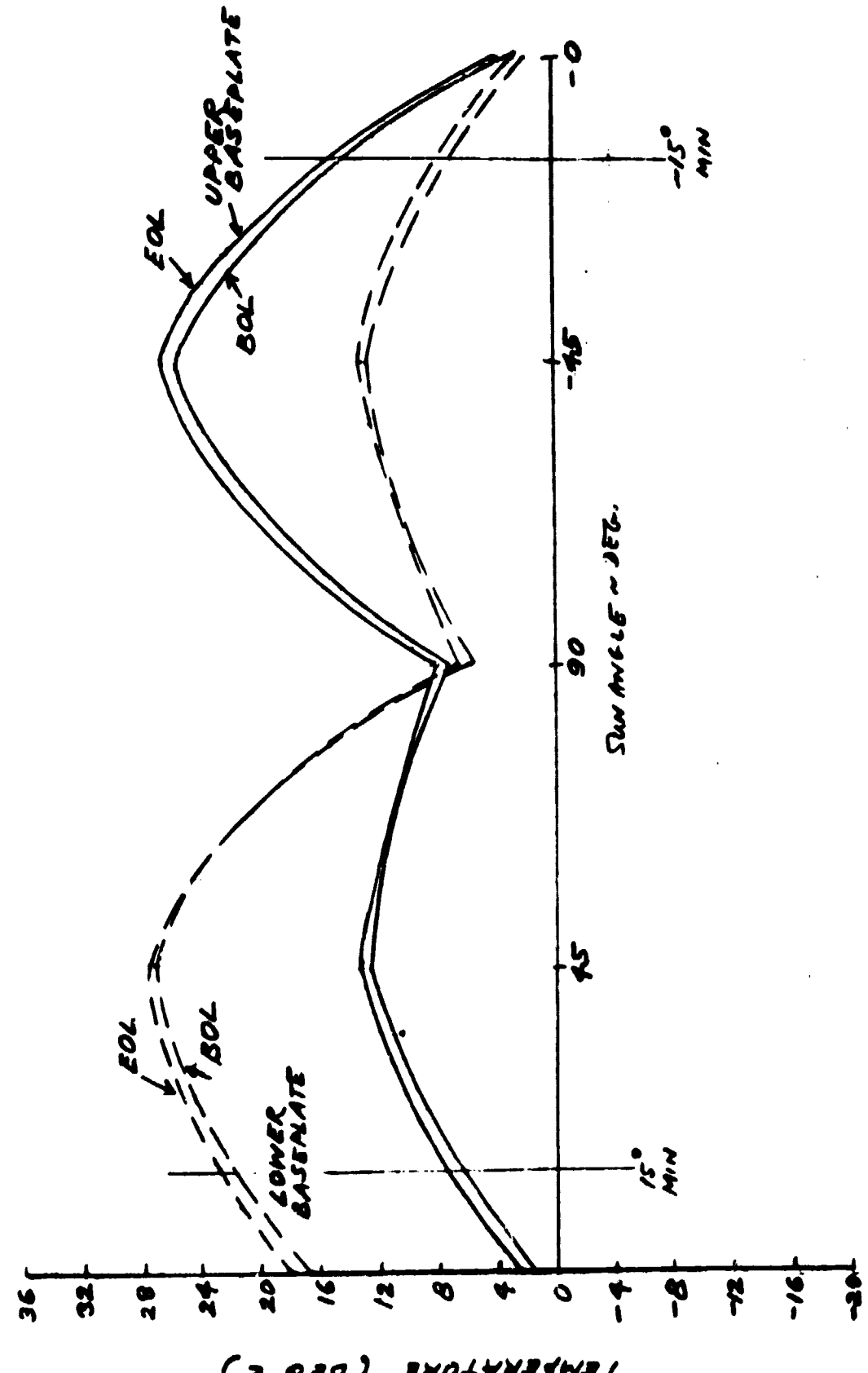


TABLE 2. DE-A THERMAL PERFORMANCE: ORBIT-AVERAGE STEADY-STATE TEMPERATURE PREDICTIONS

Description	Duty Cycle of Science Payload (%)	Sun Angle (degree)	Temperature Predictions Without TCE Heater Power (°C)				Reference	Comments
			Upper Baseplate		Lower Baseplate			
			BOL	EOL	BOL	EOL		
Injection, prior to Final On-Orbit Configuration: Non-Operational for the Science Payload	0	0	-16.0	-15.0	3.0	4.0	Figure 4	With spacecraft sensitivity of 0.35°/watts, this will require about 46.0 watts of heater power for 0% duty cyle at 0-degree sun angle to bring the baseplate temperature to 0°C.
		90	-12.0	-11.0	-9.0	-8.4		
Nominal Power Dissipation: Operation for the Science Payload	62 (Maximum)	15	6.2	7.2	21.6	22.6	Figure 5	Thermal Transients and gradients as well as uncertainty factors are applied to the maximum temperature of 27.5°C to arrive at the upper limit estimate of 35°C.
		45	12.4	13.2	27.0	27.5		
		90	7.2	8.0	5.5	6.4		
		-45	25.6	26.5	12.4	13.0		
		-15	14.0	15.2	7.0	7.7		

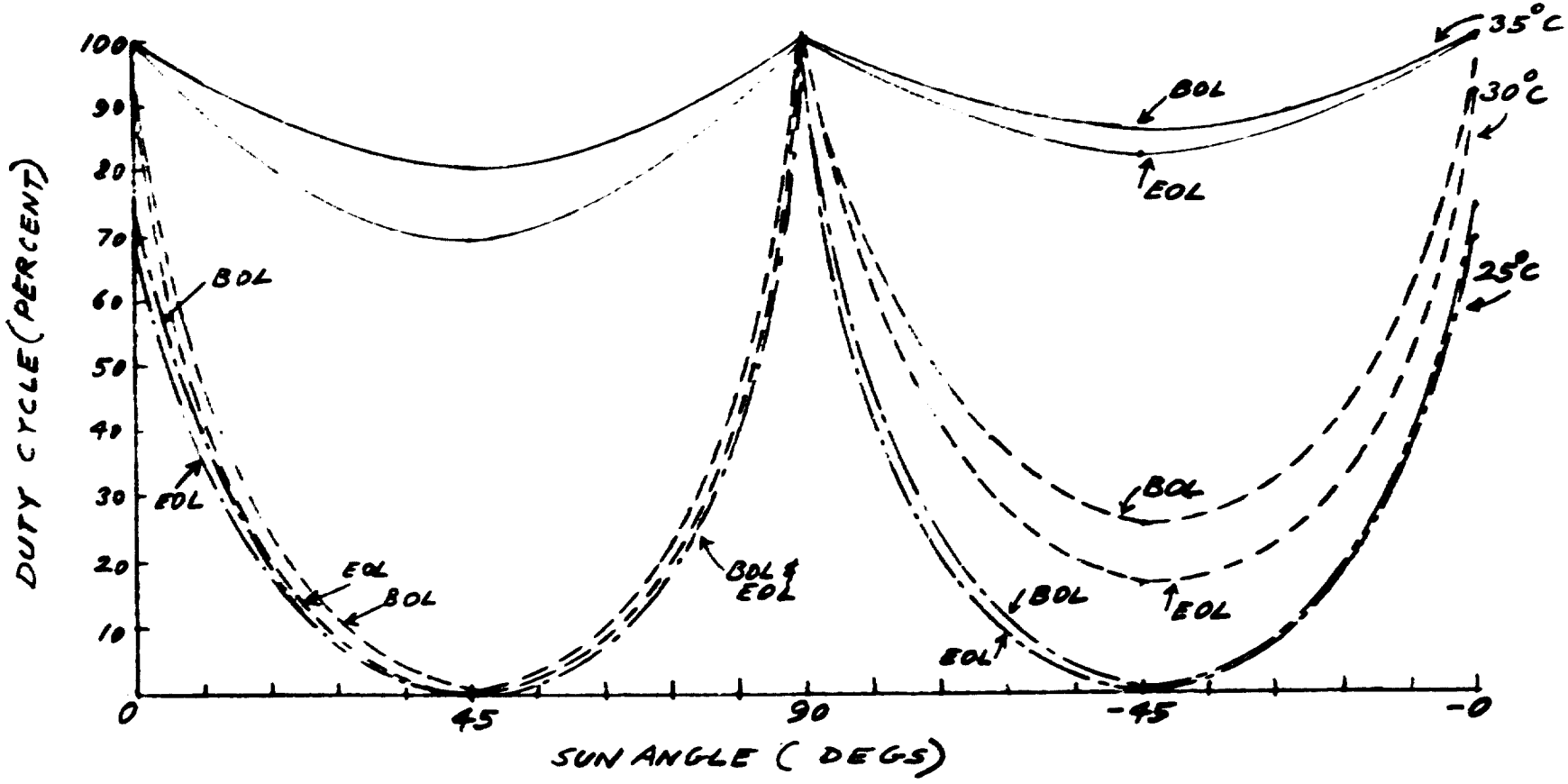
This minimum temperature combined with the same factors mentioned above, as well as the fact that the ATCE heater set-point will be set at 1°C (heater starting to turn-on) to 0°C (heater full-on), guarantees that the lower temperature of the mounting surfaces will not be allowed to go below 0°C. This combination of maximum EOL temperature and minimum BOL temperature on the lower baseplate then dictates the thermal performance of the mounting surfaces to be from 0°C to +35°C. Since the thermal switch in the PSE automatically switches off at 37-1/2 ±2-1/2°C, the batteries will require special attention for DE-A. Proper strategic location and accurate thermal-gradient prediction will be required to optimize battery performance during the hot sun angle of ±45 degrees (±5 degrees) during mission life. If that upper temperature cannot be reduced appreciably, reduced duty cycles may be suggested for the hot sun-angle periods.

3.1 Duty-Cycle Variations

Figure 6 shows DE-A Science payload duty cycles as function of sun angle for various mounting-surface interface high-temperature limits. These plots have been generated utilizing data from Figures 2 and 3 and have been corrected for thermal transients, gradients, and uncertainty factor. These plots indicate that as the upper allowable temperature limit of the mounting surfaces (baseplates) is lowered, the permissible duty cycle also has to be reduced. For the required 62-percent duty cycle of the Science payload, EOL 35°C curves meet the performance criteria. If for any reason higher duty cycles are demanded, the allowable temperatures of the mounting surfaces will also have to be higher than the present 35°C performance limit. Actual duty cycles as a function of power available as well as the upper temperature limit set by the thermal control will finally dictate the composite duty-cycle performance of the DE-A spacecraft.

FIGURE 6

DE-A DUTY CYCLE (SCIENCE + PLAYBACK) VS SUNANGLE
FOR VARIOUS S/C INTERFACE TEMPERATURE SPECIFICATION LIMITS



3.2 Solar-Array Thermal Performance

The end solar array panels on the DE-A hats are continuous with no cutouts and have internal surfaces of different finishes, depending on whether the area is controlled by the ATC's or is passive. The ATC parts of the end solar array panels are called the top-ATC and bottom-ATC area. It is these areas that house the louver actuator housings. The temperature of the ATC part of the end solar array is of interest, because the ATC support configuration will have to be isolated from it. The data for the average duty cycle of 50% of Science payload is plotted in Figure 7 and significant points are listed in Table 3.

The orbit-average temperatures of side array as function of sun angle is shown in Figure 8. For the 90-degree sun angle, the day-time average temperature of the side array is computed to be $+13^{\circ}C$.

The effect of aerodynamic heating, significant at the 190-km minimum perigee altitude of the DE-A mission, has not been examined so far, but will be investigated in detail to arrive at optimum solar-array performance. At present, it is noted that since the DE-A (spinning mode) altitude is higher than that of the Atmosphere Explorer (despun) mission, the effect will be far less critical for the DE-A mission than that accommodated on Atmosphere Explorer.

FIGURE 7

DE-A TOP ATC (NODE 3) AND TOP PASSIVE AREA (NODE 4), BOL VS EOL
50% DUTY CYCLE OF SCIENCE PAYLOAD

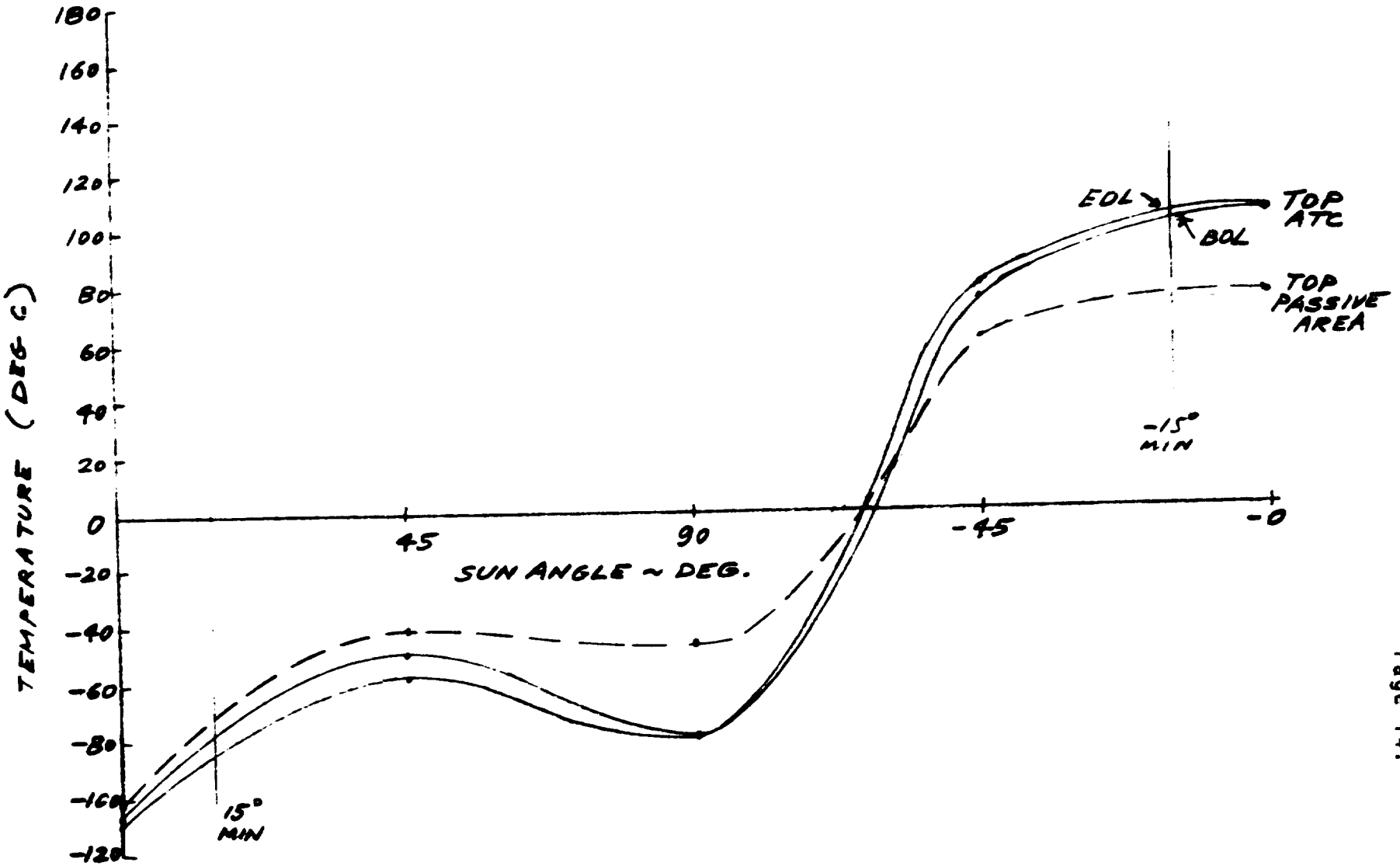


TABLE 3. SOLAR ARRAY TEMPERATURE FOR ORBIT-AVERAGE STEADY-STATE AT 50% DUTY CYCLE OF SCIENCE PAYLOAD

Solar Array	Sun Angle (degree)	Orbit-Average Temperature (°C)		Reference
		BOL	EOL	
Top-ATC of End solar Array	15	-76	-85	Figure 7
	45	-50	-56	
	90	-80	-80	
	-45	70	80	
	-15	102	104	
Upper Side Array	15	-52	-50	Figure 8
	45	-10	-10	
	90	-10	- 8	
	-45	10	12	
	-15	-16	-16	

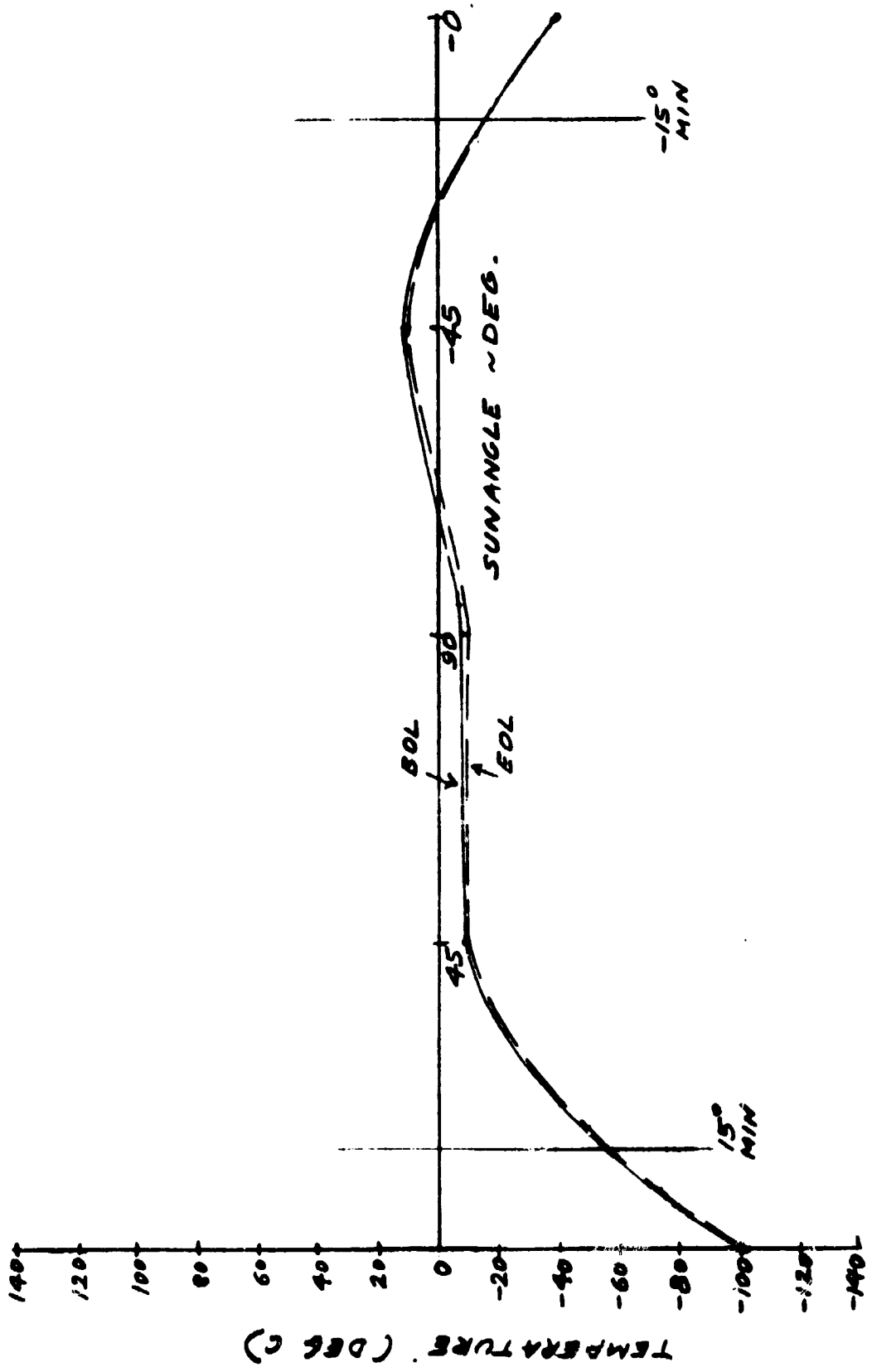


FIGURE 8
DE-A UPPER SIDE ARRAY
AVERAGE OF NODES 10, 11, 12 & 13 BOL VS EOL
50% DUTY CYCLE OF SCIENCE PAYLOAD

4.0 DISCUSSION

Table 2 shows that the steady-state upper bulk temperature limit of 35°C is obtained after adding certain allowances for thermal transients (±2°C), thermal gradients (±2°C) and the uncertainty factor (±3°C). This uncertainty factor accounts for several tolerance numbers, such as inaccuracy resulting from simplification of physical characteristics into thermal model, inadequate power dissipation data, inaccurate representation of actual conductive couplings, etc. Note that degradation of surface properties is accounted for by assuming BOL and EOL values. Whatever trade-off studies are to be undertaken, this total of ±7°C will be applied to the maximum baseplate temperature obtained through the computer analysis. In an attempt to reduce the maximum bulk temperature of 35°C to 25°C, the steady-state computer maximum EOL baseplate temperature of 18°C will be the design goal. After the detailed model transient analysis is carried out, the first two factors, transients and gradients, can be dropped as the detail model will address to these effects; however, the uncertainty factor of ±3°C will still be applicable.

Table 4 provides thermal specification limits for DE-A spacecraft. Several instruments as well as tape recorders have an upper operational temperature limit of 35°C. The batteries have upper operational limit of 40°C for limited depth of discharge and duty cycles only; it would be preferable to lower this limit. While the need for the SAI upper limit of 25°C is not apparent, attempts will be made to lower the spacecraft bulk temperature from 35°C to 25°C.

TABLE 4. DE-A THERMAL SPECIFICATIONS

ITEM	Allowable Temperature Limit Non-Operational 0_c MIN	Non-Operational 0_c MAX	Operational 0_c MIN	Operational 0_c MAX	COMMENTS
MAG Electronics	-25	50	-10	40	
MAG Boom Heat Sink	-60	60	-40	40	
PWI Electronics & Preamplifier	-40	60	-20	50	
PWI Tubular & Wire Antenna	-20	40	0	30	External to spacecraft.
SAI	-25	45	-15	25	Preferred temperature range is 0^oc to 20^oc
HAPI	-35	40	0	35	
RIMS	-40	60	-20	40	
EICS	-40	55	0	35	
BHS	-5	45	0	35	
BATTERY	-5	40	0	40	Maximum operational limit is applicable for limited DOD and cycles only.
TR	-17	35	-17	35	Performance specification: GSFC-DE-100-21-0
TRANSPONDER (NST)	-25	70	-15	50	

NOTES: 1. All limits are applicable on unit mounting interface.

2. Temperature limits of all GFE items have been obtained from the latest UNDOCS information.

To meet the temperature specification for the DE-A spacecraft following operating parameters will be considered:

- 67.5% duty cycle of science and playback load
- Sun angle = $\pm 45^{o}$ (hot case), $\pm 18^{o}$ and 90° (cold case)
- 14.5" diameter ATC louvers
- Maximum EOL bulk temperature = $25^{o}C$
- Maximum EOL computer baseplate temperature = $18^{o}C$
- Minimum BOL bulk temperature = $0^{o}C$
  (obtained through use of baseplate heaters, if necessary)
- Design to have some positive louver margin, if possible (if louvered configuration is used) at hot end.
- Design to have some positive heater margin at cold end.

APPENDIX A

PRINTOUT OF COMPUTER PROGRAM OF
STEADY-STATE TEMPERATURE PREDICTIONS
FOR
33.75% DUTY CYCLE OF
SCIENCE AND PLAYBACK PAYLOAD

Table A-1. Look-up Tables

RADIATION COUPLING FROM NODE 1 TO NODE 3*

RADIATION COUPLING FROM NODE 3 TO NODES 10, 11, 12, and 13*

RADIATION COUPLING FROM NODE 1 TO NODE 12*

RADIATION COUPLING FROM NODE 3 to NODE 22*

*Corresponds to louver active set point of 12°C (louver start to open) to 13°C (louver fully open). Varies radiation coupling as a function of baseplate temperature.

Table A-2. Nodal Radiation Couplings (in^2)

1	2	787.000000	1	3	-1.001000	1	4	31.649994	1	10	27.600006
1	11	27.600006	1	12	27.600006	1	13	27.600006	1	14	7.700000
1	15	7.700000	1	16	7.700000	1	17	7.700000	1	18	3.600000
1	19	3.600000	1	20	3.600000	1	21	3.600000	1	22	-6.001000
2	3	74.999994	2	6	31.649994	2	7	646.500000	2	10	7.700000
2	11	7.700000	2	12	7.700000	2	13	7.700000	2	14	27.600006
2	15	27.600006	2	16	27.600006	2	17	27.600006	2	18	3.600000
2	19	3.600000	2	20	3.600000	2	21	3.600000	3	4	2.500006
3	10	-2.001000	3	11	-2.001000	3	12	-2.001000	3	13	-2.001000
3	22	-4.101000	4	10	0.360000	4	11	0.360000	4	12	0.360000
4	13	2.500000	4	22	7.750000	5	6	2.500000	5	7	18.399994
5	14	2.500000	5	15	0.850000	5	16	0.850000	5	17	0.850000
6	7	7.750000	6	14	0.360000	6	15	0.360000	6	16	0.360000
6	17	0.360000	7	8	224.199997	7	9	6.200000	7	14	13.600000
7	15	13.600000	7	16	13.600000	7	17	13.600000	8	9	3.000000
10	22	13.600000	11	22	13.600000	12	22	13.600000	13	22	13.600000
22	23	224.199997	22	24	6.200000	23	24	3.000000			

Table A-3. Conductive Coupling Between Nodes (w/^{o}C)

1	2	1.250000	1	10	0.628000	1	11	0.628000	1	12	0.628000
1	13	1.628000	1	22	1.260000	2	7	1.260000	2	14	0.824000
2	15	0.824000	2	16	0.824000	2	17	0.824000	3	4	0.630000
4	17	1.260000	4	11	0.500000	4	12	0.500000	4	13	0.500000
4	21	1.000000	5	6	0.050000	6	7	0.100000	6	14	0.500000
6	15	0.500000	6	16	0.500000	6	17	0.500000	7	7	0.200000
10	11	0.040000	10	13	0.040000	10	18	0.090000	11	12	0.040000
11	14	0.090000	12	13	0.040000	12	20	0.090000	13	21	0.090000
14	14	0.040000	14	17	0.040000	14	19	0.090000	15	16	0.040000
15	19	0.040000	16	17	0.040000	16	20	0.090000	17	21	0.090000
18	19	0.027000	19	21	0.027000	19	20	0.027000	20	21	0.027000
20	20	0.027000									

Table A-4. Radiation Coupling from Node to Sink (in^{2})

1	1	56.783005	2	16	62.518997	3	1	802.560000	4	1	752.100698
5	1	10.000000	5	10	752.100098	7	17	9.500000	8	17	4.900000
9	11	4.900000	11	8	633.899902	11	8	633.899902	12	4	633.899902
12	5	633.899902	14	6	633.899902	15	7	633.899902	16	8	633.899902
17	9	633.899902	18	11	34.399994	19	2	34.399994	20	13	34.399994
21	14	34.399994	22	17	4.900000	23	17	4.900000	24	17	10.000000

Table A-4. Thermal Sink Value for Sun Angle = 0° (watts/ in^{2})

1	0.00	2	0.0000	3	0.0000	4	0.0000	5	0.0000	6	0.0000
7	0.0000	8	0.0000	9	0.0000	10	0.0000	11	0.0000	12	0.0000
13	0.0000	14	0.0000	15	0.0000	16	0.0000	17	0.0		

Table A-5 Temperature Distribution (^{o}C) for Various sun angles at 33.75% Duty Cycle

BOL; 0° Sun Angle

1	-7.3198	2	9.2356	3	-107.6909	4	-108.5672	5	102.4817	6	73.4639
7	[illegible]	[illegible]	20.4563	9	99.9712	10	-99.3896	11	-96.8295	12	-98.8295
[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible]	16	[illegible]	17	[illegible]	18	-72.7811
19	-72.4434	20	-72.4434	21	-72.7811	22	-14.6150	23	-15.8181	24	-54.8695

BOL; 45° Sun Angle

1	[illegible]	2	[illegible]	3	-59.4593	4	-41.6700	5	74.9661	6	61.3303
7	[illegible]	8	31.4872	9	76.4895	10	-9.1966	11	-9.0396	12	-8.8730
[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible]	16	[illegible]	17	[illegible]	18	5.7360
19	1.1141	20	[illegible]	21	6.6713	22	6.3223	23	4.9023	24	-38.2196

BOL; 90° Sun Angle

1	-3.6423	2	-6.9309	3	-79.6445	4	-47.3445	5	-79.1861	6	-47.8941
7	[illegible]	8	-5.8879	9	-14.2263	10	-10.0149	11	-10.8840	12	-9.9016
[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible]	16	[illegible]	17	[illegible]	18	[illegible]
19	-5.7[illegible]	20	-6.5769	21	-6.2651	22	-5.9661	23	-7.0371	24	-15.2749

BOL; -45° Sun Angle

1	[illegible]	2	12.4690	3	74.9059	4	61.0808	5	-56.6942	6	-41.4489
7	[illegible]	8	[illegible]	9	-38.3868	10	10.8721	11	10.9883	12	11.1381
[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible]	16	[illegible]	17	[illegible]	18	[illegible]
19	[illegible]	20	[illegible]	21	5.6499	22	27.0303	23	29.5256	24	77.8750

BOL; -0°C Sun Angle

1	[illegible]	2	-5.2576	3	102.4067	4	72.9872	5	-188.3736	6	-102.6524
7	-15.7768	8	-14.6015	9	-53.4184	10	-39.4511	11	-39.1986	12	-39.1985
[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible]	16	[illegible]	17	[illegible]	18	[illegible]
19	-73.[illegible]737	20	-73.6737	21	-73.8866	22	15.6182	23	28.4473	24	99.8413

EOL; 0^0 Sun Angle

RESULTANT MATRIX OF 4 ITERATION FOR T											
1	-8.4107	2	10.0277	3	-110.1973	4	-103.1009	5	106.5286	6	77.5880
7	17.7156	8	22.4186	9	100.3101	10	-102.1429	11	-101.5688	12	-101.5710
13	1.2191	14	37.5474	15	-37.3378	16	-37.3474	17	-38.3837	18	-73.6290
19	-73.6149	20	-73.6390	21	-74.0378	22	-13.8960	23	-15.1067	24	-54.3016

EOL; 45^0 Sun Angle

RESULTANT MATRIX OF 4 ITERATION FOR T											
1	12.4207	2	26.0901	3	-59.4335	4	-42.2375	5	78.3416	6	64.6309
7	-9.0174	8	32.1953	9	78.7136	10	-9.1726	11	-9.3428	12	-8.8496
13	-9.1334	14	12.1418	15	11.9807	16	12.3738	17	11.9111	18	16.7979
19	2.7939	20	19.9388	21	17.6960	22	6.1731	23	4.7549	24	-38.3391

EOL; 90^0 Sun Angle

RESULTANT MATRIX OF 4 ITERATION FOR T											
1	-2.7936	2	9.0384	3	-80.9647	4	-47.3118	5	-80.5022	6	-47.0625
7	-8.0782	8	-4.1624	9	-13.7249	10	-8.4097	11	-8.8462	12	-8.2981
13	-8.9343	14	-8.9096	15	-8.7856	16	-8.1575	17	-8.2234	18	13.1360
19	-2.8296	20	13.1652	21	14.2073	22	-5.0215	23	-6.0645	24	-14.7637

EOL; -45^0 Sun Angle

RESULTANT MATRIX OF 4 ITERATION FOR T											
1	23.0271	2	12.5044	3	78.5583	4	64.3699	5	-56.7312	6	-42.8207
7	9.4753	8	4.5588	9	-38.4972	10	11.6079	11	11.4458	12	11.6645
13	11.4143	14	-9.5191	15	-9.5165	16	-9.0151	17	-9.2783	18	16.5308
19	2.4365	20	16.6626	21	17.4807	22	27.8306	23	30.2920	24	78.1140

EOL; -0^0 Sun Angle

RESULTANT MATRIX OF 4 ITERATION FOR T											
1	10.0698	2	-4.5425	3	106.9810	4	77.3462	5	-110.9031	6	-105.2906
7	-12.5461	8	-13.2764	9	-52.8385	10	-39.1854	11	-38.9331	12	-38.9332
13	-44.1454	14	-104.0220	15	-104.0220	16	-104.0220	17	-104.4470	18	-75.2542
19	-75.0377	20	-75.0377	21	-75.2542	22	17.2029	23	21.9360	24	100.1946

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No.
	3.2.2-004-DN

Title

DE-A PARAMETRIC THERMAL STUDY

Written by: C. Chhatpar	Date October 3, 1978
Approved by: W. V. Fuldner	Date 17 Oct 78
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REVISIONS

Letter	Description	Date	Author

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D. Shipley

1. Summary

As recommended in 3.2.2-003-DN, the upper temperature specification limit of 35°C obtained for the baseline thermal design has to be lowered to 25°C. This design note describes various design configurations and their performance, along with advantages and disadvantages of each. Following configurations are investigated in ths parametric study:

1. Various cutouts in the end panel for ATC's to allow baseplate complement to directly view the space.
2. Lowering the operational active louver set points, thereby allowing the non-controlled baseplate to be coupled to a cooler controlled baseplate.
3. Increase conductive coupling between the baseplates by conventional means.
4. Incorporation of heat pipes ("Goddard Groove" Isothermalizer type) to conductively couple the two baseplates.

It is shown (see Section 3.5) that by combination of significant features of various configurations, it is possible to achieve upper maximum bulk temperature of 25°C. However, failure analysis as well as testing complexities make this configuration less attractive.

2. General

In discussing various configurations, the analysis concentrates on the following parameters:

- 67.5% duty cycle of science and playback payload. This is considered as maximum required duty cycle and is defined as the percent of every orbit time that the instruments with their playback stay on. The steady state temperature computations performed by the computer program consider this input as an orbit average internal power dissipation distributed between the upper and lower baseplates. No distinction is made as to which particular instruments are turned on and for how long. Only total bulk power dissipation is required to generate the bulk temperatures.

- Temperature predictions for $\pm 45^{\circ}$ sun angle, EOL values are shown to be the maximum bulk temperatures and are primarily discussed whenever comparison to upper bulk temperature limit of 25° is considered.

- Thermal gradients ($\pm 2^{\circ}C$), thermal transients ($+2^{\circ}C$) and uncertainty factor ($\pm 3^{\circ}C$) are lumped together to give $\pm 7^{\circ}C$ error margin on computer generated maximum steady state bulk temperatures. These factors require maximum analytical predictions of $18^{\circ}C$ to give maximum bulk temperature of $25^{\circ}C$.

3.1 ATC Cutouts in End Array (Configuration 1)

The baseline configuration described in 3.2.2-003-DN consists of 6 louvers at each flat end of the spacecraft, with no cutouts in the end panels. The anti-sun facing end array acts as a radiator sink for the ATC's, with the controlled baseplate viewing radiator or insulator or a combination of the two segments of the inside of the end array. Under worst case hot use, say $\gamma = +45^{\circ}$, the upper baseplate then effectively sees a $-60^{\circ}C$ end array, not quite an effective sink compared to space sink.

More efficient way of dumping heat through the louvers would be to provide cutouts in the end array to allow the baseplate to directly view the space. This, however, means that no solar cells can exist in the area cutout. Hence the degree of cutouts have to be compatible with the required number of solar cells to provide minimum power necessary at $\gamma = 0^{\circ}$ during initial maneuver of the spacecraft.

Following constraints enter into overall consideration:

a) Instrument payload accommodation, sepcifically $\pm$ Z RIMS.
b) S-Band antenna bracket accommodation.
c) Conductive bare-metal area requirements (can be thermally acceptable by painting with Goddard 'Green').
d) Mechanical interface requirements.
e) Cold patches at center hubs of ATC's to locally cool the bi-metal housings under worst case hot sun angles to allow actuator to closely track the baseplate temperatures under control.
f) Minimum number of solar cells required to meet $\gamma = 0^{\circ}$ power requirements.
g) Problems at hot end with solar flux impinging upon closed louvers.

A preliminary parametric study was conducted to evaluate the feasibility of using smaller diameter ATC's to accommodate RIMS. The study showed that the baseline ATC diameter of 14.5" was necessary to offer any appreciable performance improvements. The ATC diameter variation was dropped from further parameteric study. The RIMS has been accommodated by certain other rearrangements.

As pointed out earlier, 67.5% duty cycle, 45° sun angle, EOL bulk temperature of $25^{\circ}C$ is the design goal. For a double bladed louver design, the maximum cutout per ATC segment can be 60°. Table 1 and 2 provide data for variable parameters for 20° and 40° ATC cutouts respectively. Other fixed parameter data for this simplified thermal model is given in DE design note 3.2.2-001-DN.

Temperature performance for 0°, 20° and 40° cutouts are plotted in Figure 1 and are extrapolated to full 60° cutouts. Note that 0° cutout data corresponds to no cutout in end array described in 3.2.2-003-DN. Also plotted on the same figure are number of solar array strings on end panels. Power subsystem requirements dictate that at least 8 strings be available, giving roughly 55° ATC cutout possibility.

Figure 1 shows that as the ATC cutouts are increased, there is an insignificant drop in the lower (hotter for $\gamma=+45^{\circ}$) baseplate temperature, for a $12^{\circ}C$ louver setpoint on the upper baseplate. The louver margin increases significantly, meaning that not as much of louver rotation is required as provided. This is because the controlled baseplate (upper in this case) is always between $12^{\circ}C$ and $13^{\circ}C$ no matter how much additional heat dumping capability is provided. The hotter baseplate is always coupled to this $12^{\circ}C$-$13^{\circ}C$ sink, resulting in negligible drop in temperature.

If cooling of the hotter baseplate is required, then it will be necessary to couple it to a cooler controlled baseplate. This translates into a lower louver active set point.

Hence this parametric study indicates that merely providing ATC cutouts in end arrays does not meet the bulk temperature specification requirements of $25^{\circ}C$.

TABLE 1. Variable Parametric Values for 20° ATC Cutout Configuration

FROM NODE	TO NODE	INTERNAL RADIATION COUPLING (IN^2) LOUVERS FULLY CLOSED	LOUVERS FULLY OPEN	COMMENTS (see note 1)
1	3	69.0	280.05	Variable values for $\gamma<90^\circ$; fully closed lvrs values for $\gamma>90^\circ$
1	22	646.5	536.5	" " " " " "
2	5	69.0	280.05	" " $\gamma>90^\circ$; fully closed lvrs values for $\gamma<90^\circ$
2	7	646.5	536.5	" " " " " " "
3	10	.85	5.0	" " $\gamma<90^\circ$; " " " " $\gamma>90^\circ$
3	11	.85	5.0	" " " " " " "
3	12	.85	5.0	" " " " " " "
3	13	.85	5.0	" " " " " " "
3	22	18.4	107.1	" " " " " " "
5	7	18.4	107.1	" " $\gamma>90^\circ$; " " " " $\gamma<90^\circ$
5	14	.85	5.0	" " " " " " "
5	15	.85	5.0	" " " " " " "
5	16	.85	5.0	" " " " " " "
5	17	.85	5.0	" " " " " " "
NODE	SINK	EXTERNAL RADIATION	COUPLING (IN^2)	
1	17	0.0	136.88	Variable values for $\gamma<90^\circ$; fully closed lvrs values for $\gamma>90^\circ$
2	17	0.0	136.88	" " $\gamma>90^\circ$; " " " " $\gamma<90^\circ$
1	2	CONDUCTIVE COUPLING (WATTS/°C)		This value is same as used in EE analysis.
		1.25		

Note 1. Fully closed louver values are applicable for baseplate temperature below 12°C; fully open values for temperatures above 13°C. Program computes proportional values between 12°C and 13°C.

TABLE 2. VARIABLE PARAMETRIC VALUES FOR 40° ATC CUTOUT CONFIGURATION

FROM NODE	TO NODE	INTERNAL RADIATION COUPLING (IN^2) LOUVERS FULLY CLOSED	INTERNAL RADIATION COUPLING (IN^2) LOUVERS FULLY OPEN	COMMENTS (SEE NOTE 1)
1	3	69.0	156.86	Variable values for $\gamma<90^\circ$; fully closed lvrs values for $\gamma>90^\circ$
1	22	646.5	536.5	" " " " " " " " " "
2	5	69.0	156.86	" " " $\gamma>90^\circ$; " " " " " $\gamma<90^\circ$
2	7	646.5	536.5	" " " " " " " " " "
3	10	.85	5.0	" " " $\gamma<90^\circ$; " " " " " $\gamma>90^\circ$
3	11	.85	5.0	" " " " " " " " " "
3	12	.85	5.0	" " " " " " " " " "
3	13	.85	5.0	" " " " " " " " " "
3	22	18.4	107.1	" " " " " " " " " "
5	7	18.4	107.1	" " " $\gamma>90^\circ$; " " " " " $\gamma<90^\circ$
5	14	.85	5.0	" " " " " " " " " "
5	15	.85	5.0	" " " " " " " " " "
5	16	.85	5.0	" " " " " " " " " "
5	17	.85	5.0	" " " " " " " " " "
NODE	SINK	EXTERNAL RADIATION COUPLING (IN^2)		
1	17	0.0	273.75	Variable values for $\gamma<90^\circ$; fully closed lvrs values for $\gamma>90^\circ$
2	17	0.0	273.75	" " " $\gamma>90^\circ$; " " " " " $\gamma<90^\circ$
		CONDUCTIVE COUPLING (WATTS/°C)		
1	2	1.25		This value is same as used in EE analysis.

NOTE 1. Same as in Table 1.

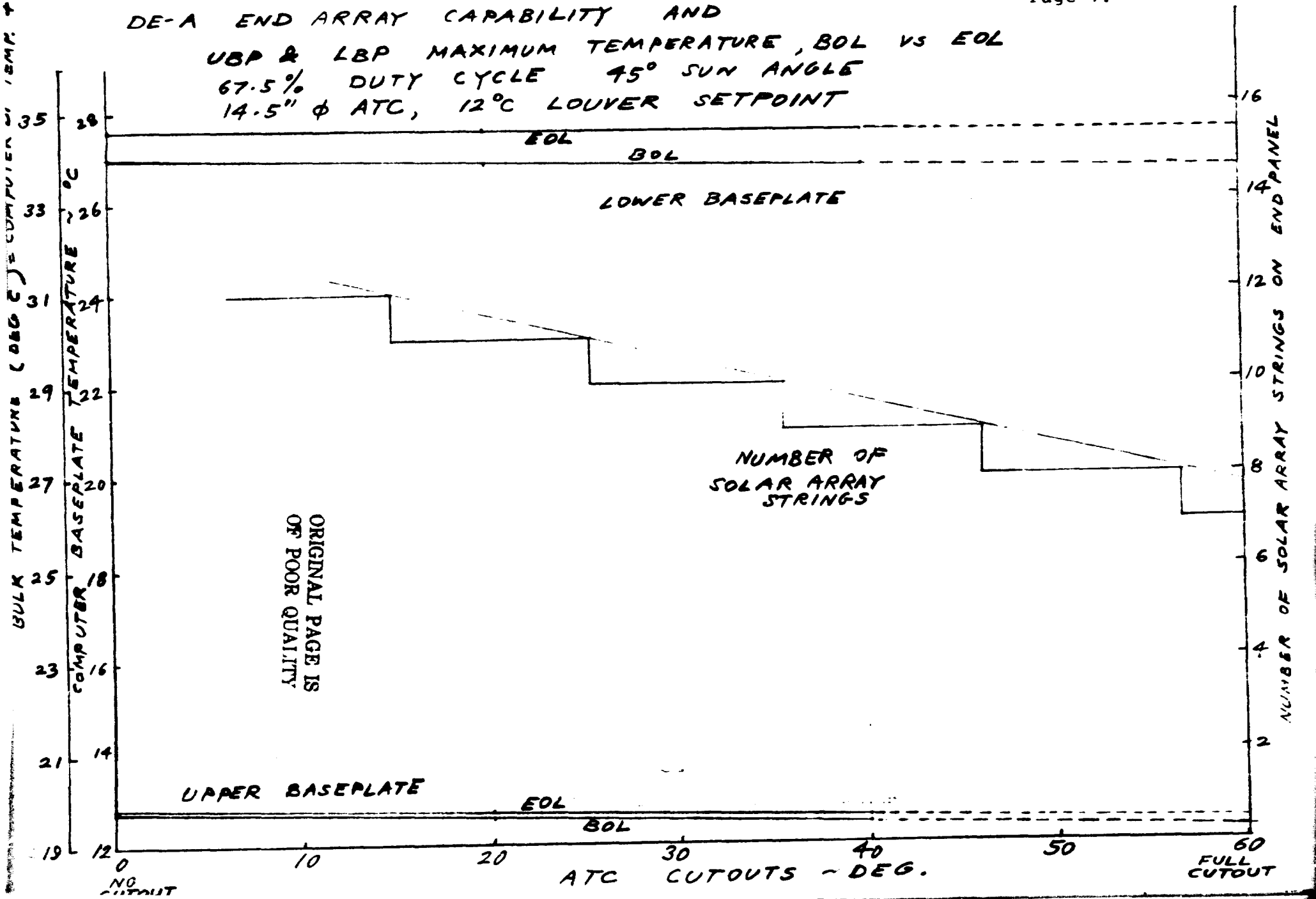
FIGURE 1

DE-A END ARRAY CAPABILITY AND

UBP & LBP MAXIMUM TEMPERATURE, BOL VS EOL

67.5% DUTY CYCLE 45° SUN ANGLE

14.5" ϕ ATC, 12°C LOUVER SETPOINT



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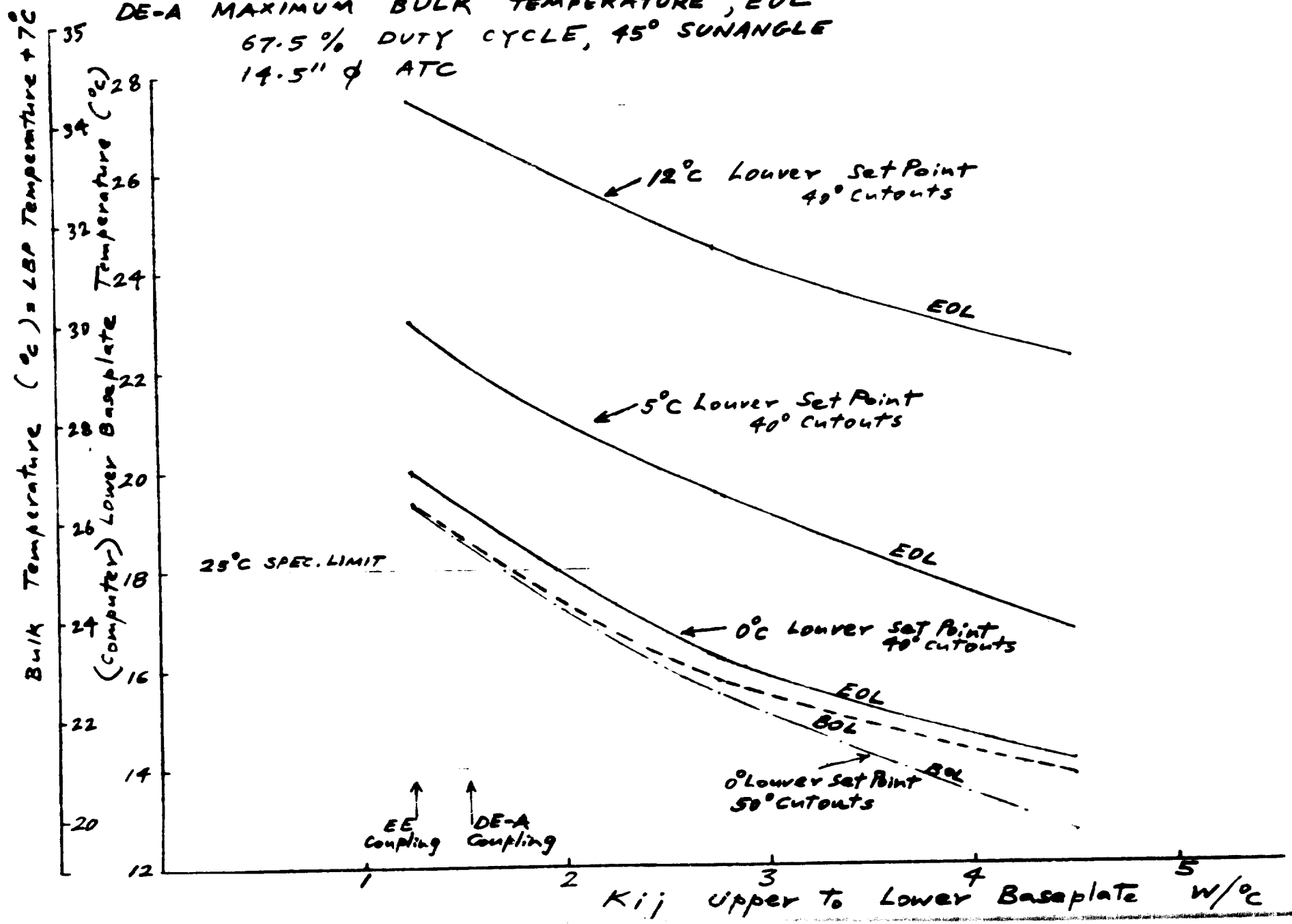
3.2 Louver Active Set Point (Configuration 2)

The louver active set point refers to a temperature of the controlled baseplate sensed by a thermistor that activates a heater on bimetallic actuator of ATC louver assembly. The set point is the temperature when louver first starts to open, with louver fully open at temperature 1°C higher. As long as there is sufficient heat dumping capability of the louver system, the controlled baseplate is always between its set point and 1°C higher. The other baseplate is likewise coupled to this almost constant temperature heat sink. All the variable parameter data as shown for the 40° ATC cutouts are applicalbe for this study, except that the louver control point is varied.

Figure 2 shows the results of 12°C, 5°C, and 0°C active louver set points for 67.5% duty cycle, 45° sun angle EOL values. Points on the figure for this parametric study correspond to K_{12} (conductive coupling between upper and lower baseplate) of 1.25 watts/°C (designated as EE coupling). While there is 4.5°C and 3° drop in temperature for changing the set point from 12°C to 5°C and 5°C to 0°C respectively, the bulk temperature specification limit of 25°C is still not met with this design modification. K_{12} = 1.25 W/°C pertains to conductive coupling as used in the EE design notes. More accurate computation of this coupling results in a slightly higher value. Note that increasing the cutouts to 50° doesn't gain much in performance.

This parametric study shows that by providing ATC cutouts in end arrays and lowering the louver set points doesn't meet the bulk temperature specification requirement of 25°C. As the Figure 2 shows, the parametric study with respect to K_{12}, the conductive coupling between the baseplates, seems to show promising results.

FIGURE 2


DE-A MAXIMUM BULK TEMPERATURE, EOL
67.5 % DUTY CYCLE, 45° SUNANGLE
14.5" ϕ ATC
Bulk Temperature (°C) = LBP Temperature + 7C°
(Computer) Lower Baseplate Temperature (°C)
35
34
32
30
28
26
24
22
20
28
26
24
22
20
18
16
14
12
12°C Louver Set Point
49° Cutouts
EOL
5°C Louver Set Point
40° Cutouts
EOL
25°C SPEC. LIMIT
0°C Louver Set Point
40° Cutouts
EOL
BOL
0° Louver Set Point
50° Cutouts
BOL
EE Coupling
DE-A Coupling
1
2
3
4
5
Kij Upper to Lower Baseplate W/°C

3.3 Conductive Coupling Between Baseplates (Configuration 3)

Figure 2 shows that for K_{12} = 1.25 w/^{o}C the maximum EOL bulk temperature is 27°C for a 0°C lower set point, still above the specification requirement of 25°C. As a result, parametric study was carried out to evaluate the effect of better conductivity coupling between the two baseplates by some means.

Figure 2 shows that for K_{12} = 2.0 w/^{o}C and 40° cutouts for ATC, the EOL bulk temperature of 25°C in obtained for a 0°C louver set point. This increase in conductive coupling can be accomplished in two conventional ways:

a) Increase thickness of shear webs connecting the two baseplates and increase wall thickness of center column.
b) Employ higher conductivity material to gain higher Kij with minimum weight increase.

Since the center column material is magnesium (K = 3.12 w/in^{o}C), any weight-effective increase in conductive coupling can be accomplished only by increasing the wall thickness. Changing the material to higher density aluminum does not contribute effectively. Hence increasing the conductive coupling by changing material and increasing thickness of shear webs is investigated. Table 4 shows candidate materials and their thermal conductivity values.

Keeping the joint conductances the same (K = .3 w/in^{2}/^{o}C for a dry joint), the increase in shear web thickness to obtain specific K_{12} results in certain weight increase, plotted in Figure 3 for three candidate materials. For a specific K_{12} from Figure 2, corresponding bulk temperature can also be obtained for a selected louver set point. This data is translated into Figure 4 which shows bulk temperature vs. total net weight change for the three candidate materials for 0°C louver set point, EOL data. This data is already corrected for weight saving obtained by eliminating doublerplates as shear web thickness increases. It appears that for a 25°C bulk operating sepcification limit, 6061-T6 for shear webs results in a net weight gain of approximately 3.5 lbs, which is considered quite acceptable.

TABLE 4.

THERMAL CONDUCTIVITY VALUES FOR CANDIDATE MATERIALS

Structure	Material		Thermal Conductivity w/in°C
Shear webs	Aluminum	2024-T4 (present)	3.0
		2014-T62	3.96
		6061-T6	4.22
Center Column	Magnesium ZK60A-T6		3.12

FIGURE 3

DE-A

CONDUCTIVE COUPLING BETWEEN BASEPLATES VS WEIGHT CHANGE FOR DIFFERENT SHEAR WEB MATERIALS

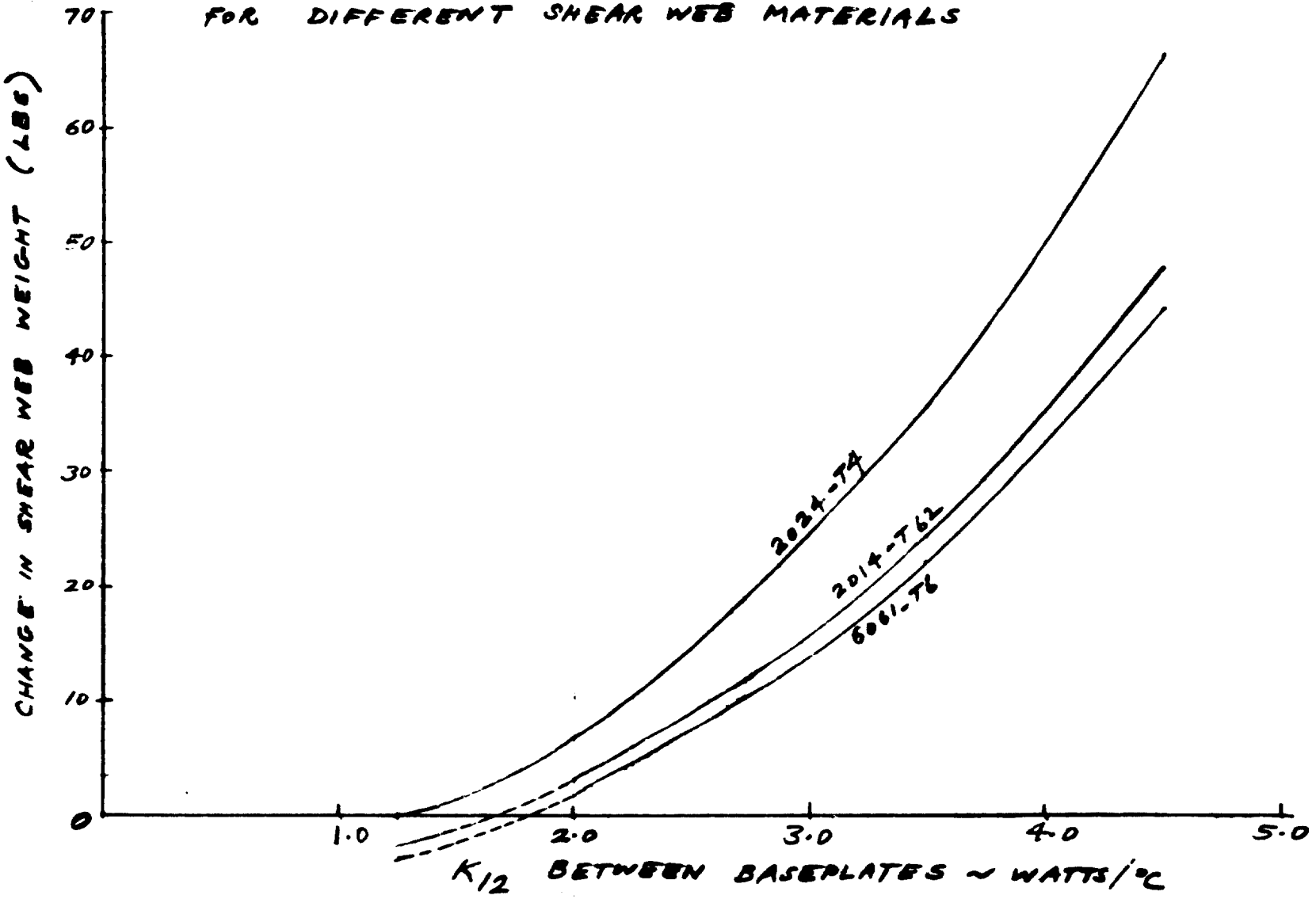
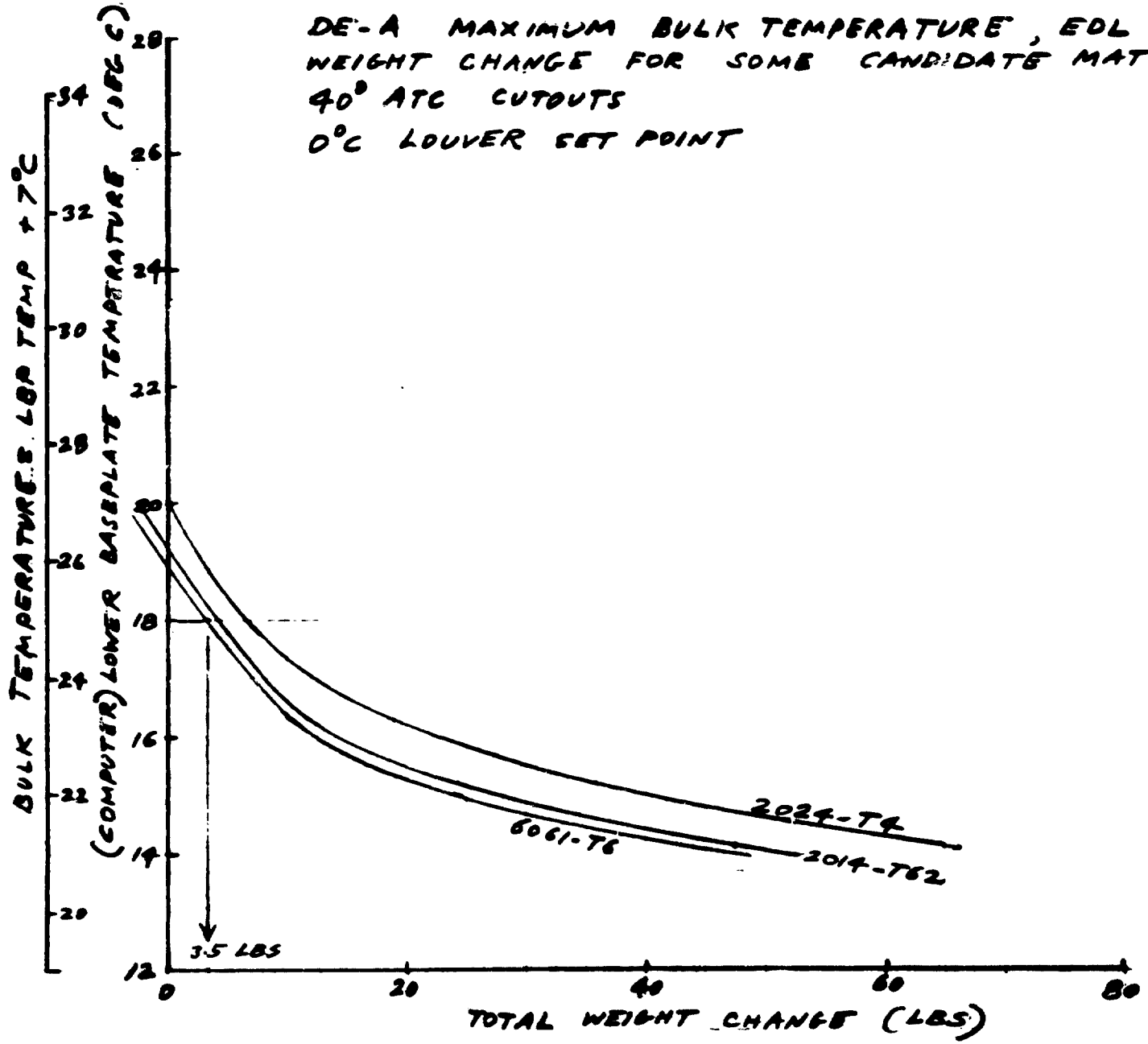


FIGURE 4

DE-A MAXIMUM BULK TEMPERATURE, EOL VS SHEAR WEB WEIGHT CHANGE FOR SOME CANDIDATE MATERIALS.
40° ATC CUTOUTS
0°C LOUVER SET POINT



3.4 Heat Pipe Configuration (Goddard 'Groove') (Configuration 4)

Figure 2 shows that increasing the K_{12} between the two baseplates has considerable effect in reducing the maximum EOL bulk temperatures. As an extrapolation effort to further increase the conductive coupling between the two baseplates, heat pipes of isothermalizer type (Goddard 'Groove') were incorporated in the simplified thermal model.

The analysis deals with heat pipe on an overall bulk basis, in that the effective increase in conductive coupling is lumped into K_{12} which represents total conductive coupling between the upper and lower baseplates. Table 5 shows design data for two configurations; one with 40° ATC cutouts and one for no ATC cutouts.

Figure 5 illustrates the performance results for the two configurations considered. Note that analysis is carried out for the baseline 67.5% duty cycle of science and playback payload for $+45^{o}$ sun angle, for a $5^{o}C$ louver set point. Only BOL data are plotted, because the intention is to discuss the overall trend of the effect of heat pipes. The actual EOL values can be obtained by adding another $1^{o}C$ to the BOL values.

3.4.1 0° ATC Cutout with Heat Pipes

The curves show that as the conductive coupling is increased by adding more heat pipes, the two baseplates get clamped together with about $3^{o}C$ asymptotic temperature differential between the two. However, the hotter of the two baseplates (lower in this case) does not cool off to $25^{o}C$ bulk temperature until at least 4 heat pipes are incorporated. The upper baseplate (the ATC controlled one in this case), on the other hand, starts out with $9^{o}C$ on the (computer) baseplate temperature while the louver set point was set at $5^{o}C$. This means that louvers will be wide open, with upper baseplate out of louver control range. Adding more heat pipes only makes the situation worse. It may, at first, appear that the final temperatures are acceptable, but without louvers maintaining control of the upper baseplate, the failure analysis of ATC's makes this configuration very undesirable.

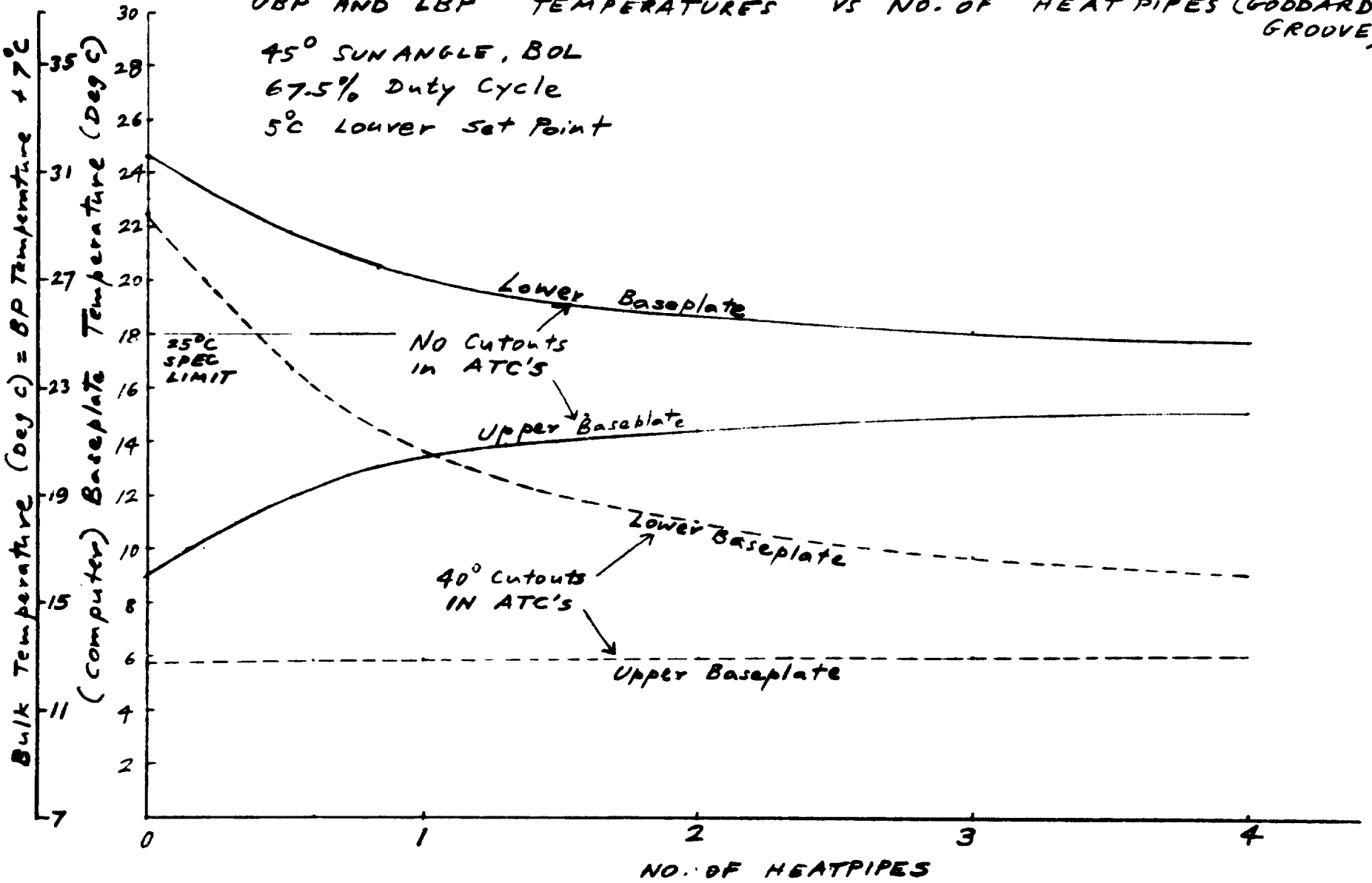
Table 5. DE-A Thermal Model Description for Inclusion of Heat Pipes

Fixed Parameter Data	Ref. DE Design Note 3.2.2-001-DN			
Variable Parameter Data	40° ATC Cutouts		0° Cutout	
(Internal and External Radiation Couplings)	Table 2 of this Design Note		Table 1 of 3.2.2-003-DN	
Variable Parameter Data (Conductive Coupling)	No. of heat pipes	K_{12} of Heat Pipe W/^{o}C	K_{12} of structure	Total K_{12} w/^{o}C
	0	0	1.25	1.25
	1	6.375	1.25	7.625
	2	12.75	1.25	14.0
	3	19.125	1.25	20.375
	4	25.5	1.25	26.75

FIGURE 5

UBP AND LBP TEMPERATURES VS NO. OF HEAT PIPES (GODDARD GROOVE)

45° SUN ANGLE, BOL
67.5% Duty Cycle
5°C Louver Set Point



3.4.2 40° ATC Cutouts with Heat Pipes

Note that the initial part of these curves (up to K_{12} = 4.5 w/^{o}C) correspond to the curves shown in Figure 2. As would be expected, the heat pipes help to clamp the two baseplates together, with the upper baseplate always between 5°C - 6°C range, indicating that the upper baseplate is always under louver control. The lower baseplate (hotter of the two, in this case) bulk temperature drops to 25°C for a K_{12} of about 3.5 W/^{o}C, indicating that at least theoretically less than one Goddard groove heat pipe is necessary to achieve the desired performance.

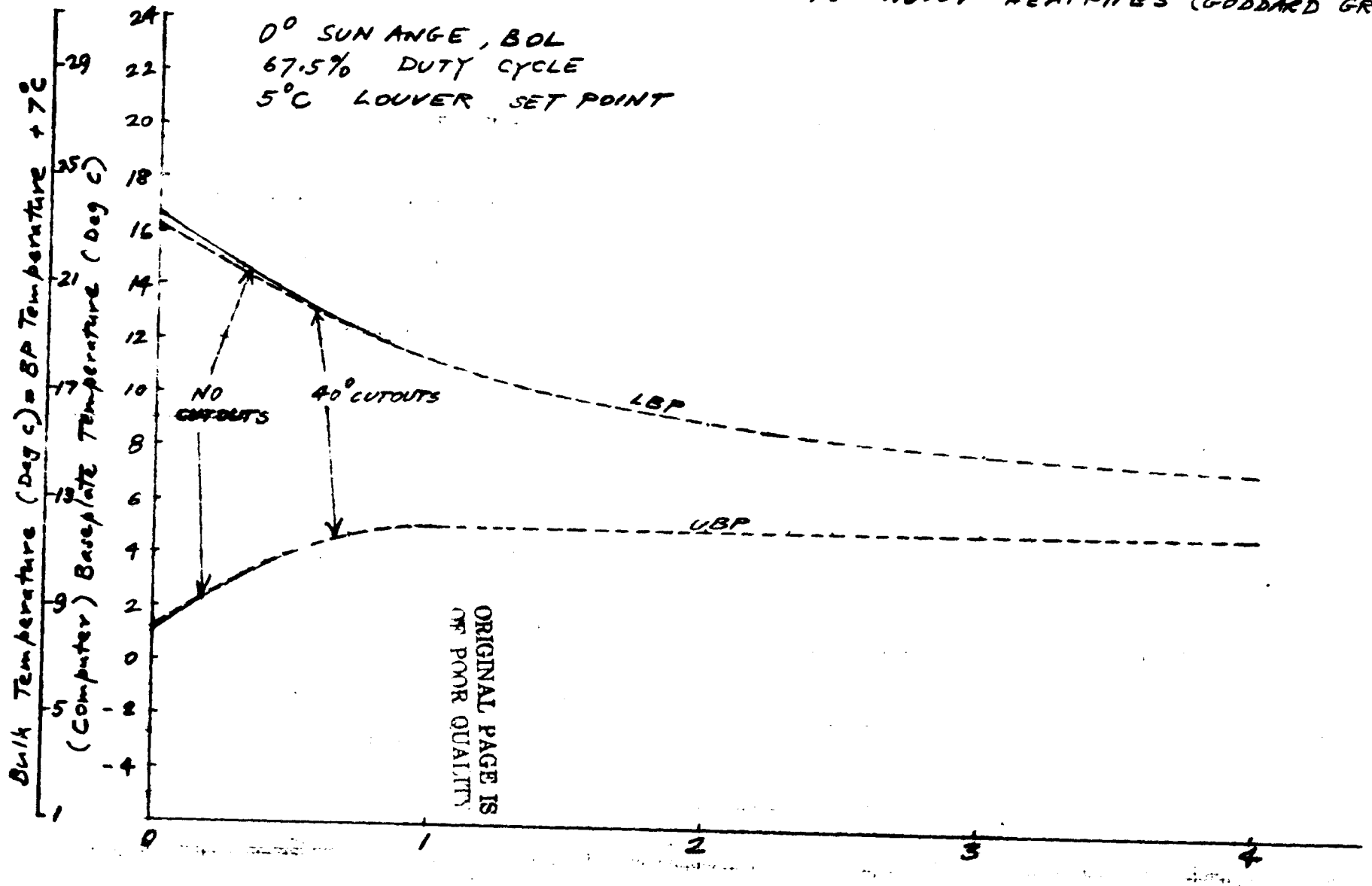
The most important piece of information is obtained by observing that the greatest drop in bulk temperature is obtained for K_{12} up to 5.0 w/^{o}C equivalent to less than one heat pipe. For across-the-baseplate-temperature-gradient reasons, it would be necessary to have at least four heat pipes, preferably six. All of which does not really contribute to improving the bulk temperature performance.

Figure 6 shows 0° sun angle BOL data for the two configurations. The heat pipes have almost the same clamping effect on the two baseplates for the two configurations.

Following comparison between the heat pipe configuration (Configuration 4) and Configuration 3 shows some interesting points:

FIGURE 6

UBP AND LBP TEMPERATURES VS NO. OF HEATPIPES (GODDARD GROOVE)



ITEM	Configuration 3. Conductive Coupling by Conventional Means	Configuration 4. Heat Pipe
1. Weight Penalty	3.5 lbs. Refer to Figure 4	Each Goddard groove heat pipe including all hardware and support bracket = 2 lbs/ heat pipe. For minimizing gradients, need 6 heat pipes. 12 lbs.
2. Gradient Problem	No such problem	If one or more heat pipes should fail, then across gradients will develop. Probably should apply higher value for gradient tolerance factor.
3. Manufacturing Complexity	Higher gage shear web will eliminate some doubler plates and simplify overall fabrication.	Will require some layout and special hardware to integrate the heat pipes.
4. Testing Complexity (component level)	No testing necessary.	Heat pipes will have to be fully qualified at component level prior to integrate with the spacecraft.
5. Testing Complexity (spacecraft level)	No such complexity experienced	Performance of heat pipes under zero g cannot be evaluated on spacecraft level. May require removing the heatpipes prior to space-craft level testing. Performance in flight cannot be verified on ground.

It appears that increasing the conductive coupling by increasing the shear web thickness to provide K_{12} = 2.0 w/^{o}C is very cost-effective and weight-effective, compared to the other techniques.

Even though 40° ATC cutouts, 0°C louver set point provides acceptable bulk temperature performance, Figure 7 shows that for K_{12} = 2.0 w/^{o}C, there is no louver margin at γ=45° for 67.5% duty cycle.

3.5 50° Cutout, 0°C Louver Set Point (Configuration 5)

As was pointed out in Section 3.1, up to 55° ATC cutout possibility exists without affecting the end solar array power. Therefore, analysis is carried out for a 50° cutout, 0°C louver set point which is also shown in Figure 7. Again, only BOL values are shown to make the design comparison. It can be seen that for 50° cutout, the upper baseplate is under active louver control for all values of K_{12} up to 4.5 w/^{o}C. For K_{12} = 2.0 w/^{o}C of interest, about 10% louver margin exists. This margin can be applied towards uncertainty in box internal power dissipations, failed louver case, etc. Following parameters constitute configuration 5:

14.5" Ø ATC
50° ATC cutouts in end panels
0°C louver set point
K_{12} = 2.0 w/^{o}C (wt. penalty of 3.5 lbs)

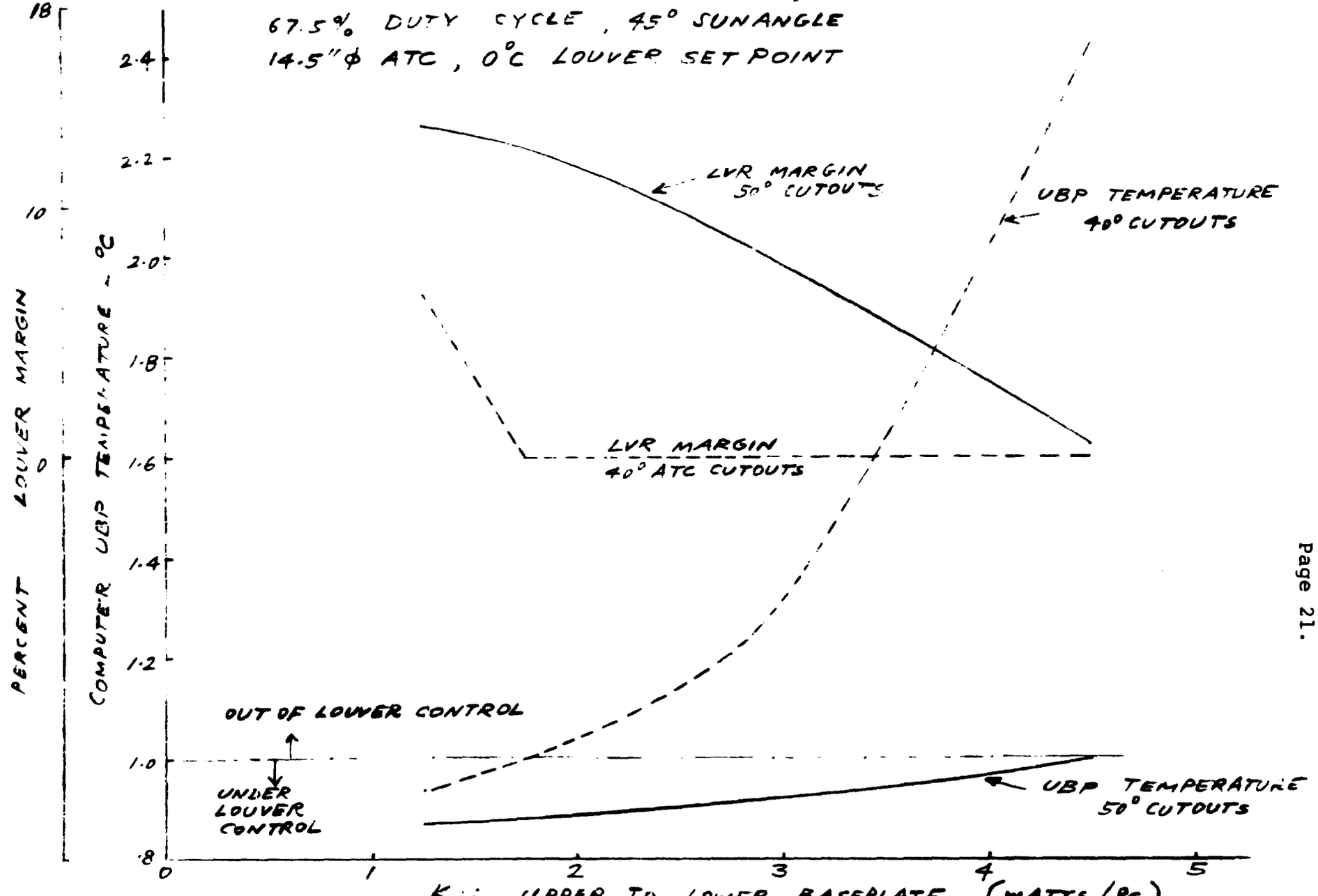
For 67.5% duty cycle of science and playback payload, 45° sun angle (hot case), this configuration provides upper EOL maximum temperature of 25°C, with approximately 10% on louver margin.

The above description would indicate that the design configuration has been evolved that meets the specification requirements, which is indeed the case. However, following two considerations throw some additional light on the situation:

a) The cutouts in the end panels would indicate the need for a solar simulation test of the ATC assemblies to provide adequate data on louver performance under solar flux impingement. This test can be complex and costly.
b) Failure analysis of louver assemblies indicates that if the louvers fail closed, the passive louver set point will eventually open up the louvers. However, if the louver happens to fail open, solar flux could penetrate the spacecraft. Depending upon which louver assembly fails open, some critical instruments could be directly illuminated by solar flux, possibly causing extensive damage.

FIGURE 7

DE-A UBP TEMPERATURE (BOL) AND LOUVER MARGIN
67.5% DUTY CYCLE, 45° SUNANGLE
14.5"ϕ ATC, 0°C LOUVER SET POINT



Hence these considerations make configuration 5 less attractive and point to the need for closing off the end array ATC cutouts.

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No.
	3.2.2-005-DN

Title

DE-A Final Thermal Design Configuration

Written by:	Date
C. Chhatpar	Oct 6 1978
Approved by: W. V. Fuldner	**Date** 17 Oct 78
This DN supplements (S), replaces (R) DN Nos. (S) 3.2.2-004-DN (S) 3.2.2-001-DN	Send one copy of this Note to the DCC (Library) attached to a copy of Form AED 1488.

REVISIONS

Letter	Description	Date	Author

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AE 1338 2 1/74

1. SUMMARY

Configuration No. 5 of 3.2.2-004-DN was shown to meet all DE-A specification requirements. However, the failed-open louver case of that configuration during orbital mission made the spacecraft susceptible to solar flux penetration upon some critical equipment. This catastrophic-type failure of some equipment as well as the fact that ATC cutout make it necessary to solar-simulate the spacecraft to evaluate the spacecraft performance made that configuration less attractive.

It was recognized that the baseplates were strongly coupled to their respective end arrays. Also, Section 3.1 of 3.2.2-004-DN indicates that 8 strings of solar cells on end array can provide sufficient power during $\gamma = \pm 18°$, which is the reason that up to 55° of ATC cutout were possible. The same area as allocated to ATC cutouts can be utilized to cool the end array, thereby lowering the maximum bulk temperatures.

2. DESIGN CONFIGURATION

In order to design in certain positive louver margin, the following parameters were selected to investigate the effect of end array temperatures on the baseplates:

67.5% Duty Cycle
45° Sun Angle
6°C Louver Set Points
K_{12} = 2.5 W/°C

Three different white paints with different BOL and EOL surface properties were selected to carry out this parametric study. Table 1 shows the preliminary end array surface property breakdown, accounting for solar cells with coverglass, ATC cold patch to decouple the end array from the actuator housing, RIMS and antenna bracket accommodation, basemetal area requirement and different paint for the available radiator area.

TABLE 1. END SOLAR ARRAY SURFACE PROPERTIES

ITEM	Area in^2	Surface Finish	10 Mil Al/Teflon(1)				Goddard White(1) NS43C				IITRIS-13GLO(1)			
			α		ε		α		ε		α		ε	
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
Solar cells .8" x .8" cell 156 cell/string 8 strings	798.72	Solar cells w/coverglass	.713	.737	.81	.81	.713	.737	.81	.81	.713	.737	.81	.81
Cold Patch ATC 4"Ø (6)	75.4	10 Al/Teflon	.15	.2	.79	.83	.15	.2	.79	.83	.15	.2	.79	.83
RIMS (78 cells)	49.92	Goddard White NS43C	.2	.3	.92	.92	.2	.3	.92	.92	.2	.3	.92	.92
Antenna Bracket (50 cells)	32.0	Goddard White NS43C	.2	.3	.92	.92	.2	.3	.92	.92	.2	.3	.92	.92
Baremetal (additional to separation adapter)	225.49	Goddard White NS43C	.2	.3	.92	.92	.2	.3	.92	.92	.2	.3	.92	.92
Radiator Area (Distributed Over Entire Area)	660.0	See (1)	.15	.2	.79	.83	.2	.3	.92	.92	.2	.4	.84	.88
Total End Array	1841.53		.4025	.45	.82	.836	.42	.485	.867	.869	.42	.521	.838	.854

Bare metal on end separation adapter=254.47
+Base metal on side

TABLE 2. Orbit Average External Sink Values for End Arrays
DE-A Spacecraft

Radiator Area Surface Properties	Sink No.	Sink Equivalent Black-Body Radiation (watts/sq.in)									
		BOL-10 rpm Apogee = 23918 km Perigee = 275 km					EOL - 10 rpm Apogee = 23918 km Perigee = 275 km				
		Orbit Sun Angle (deg)					Orbit Sun Angle (deg)				
		0	45	90	-45	-0	0	45	90	-45	-0
10 mil Al/Teflon	1	.004	.005	.006	.005	.004	.002	.003	.004	.003	.002
	10	.439	.312	.006	.312	.439	.497	.353	.004	.353	.497
NS43C Goddard White	1	.004	.005	.006	.005	.004	.002	.003	.004	.003	.002
	10	.440	.314	.006	.314	.440	.507	.359	.004	.359	.507
IITRIS-13 GLO	1	.004	.005	.006	.005	.004	.002	.003	.004	.003	.002
	10	.448	.319	.006	.319	.448	.563	.399	.004	.399	.563

TABLE 3. VARIABLE PARAMETRIC VALUES FOR FINAL CONFIGURATION

From Node	To Node	Internal Radiation Coupling (in^2) Louvers Fully Closed	Louvers Fully Open	COMMENTS (See Note 1)
1	3	69.0	408.97	Variable values for $\gamma < 90°$; fully closed lvrs values for $\gamma > 90°$
1	22	646.5	536.5	" " " " " " " " " "
1	5	69.0	408.97	" " " $\gamma > 90°$ " " " " " " $\gamma < 90°$
2	7	656.5	536.5	" " " " " " " " " " "
3	10	.85	5.0	" " " $\gamma < 90°$ " " " " " " $\gamma > 90°$
3	11	.85	5.0	" " " " " " " " " " "
3	12	.85	5.0	" " " " " " " " " " "
3	13	.85	5.0	" " " " " " " " " " "
3	22	18.4	107.1	" " " " " " " " " " "
5	7	18.4	107.1	" " " $\gamma > 90°$ " " " " " " $\gamma < 90°$
5	14	.85	5.0	" " " " " " " " " " "
5	15	.85	5.0	" " " " " " " " " " "
5	16	.85	5.0	" " " " " " " " " " "
5	17	.85	5.0	" " " " " " " " " " "
Node	Sink	External Radiation Coupling (in^2)		
1	17	0.0	0.0	Variable values for $\gamma < 90°$; fully closed lvrs values for $\gamma > 90°$
2	17	0.0	0.0	" " " $\gamma > 90°$; " " " " " " $\gamma < 90°$
1	2	Conductive Coupling (watts/°C) 2.5		Corresponds to about 7.0 lbs of weight increase in 6061-T6 shear webs.

NOTE 1. Fully closed louver values are applicable for baseplate temperatures below 6°C. Fully open louver values for temperatures above 7°C. Program computes proportional values between 6°C and 7°C.

Table 1 data translates into different external sink values for the three different materials, shown in Table 2. Table 3 shows all the variable parameter data applicable for this configuration. Note that all the fixed parameter data is given in 3.2.2-001-DN.

3.1 BASIC PERFORMANCE

Figure 1 shows the spacecraft bulk temperature for the three selected paints $\alpha S/\varepsilon$ for the radiator part of the end array. It turns out that all three meet the specification requirement of 25°C on the hotter of the two baseplates. The controlled baseplate is under louver control with some positive louver margin.

Also plotted on the same figure is the maximum end array temperature for the 0° sun angle. The data arbitrarily includes 10°C uncertainty factor for conservatism.

The IITRIS-13GLO with the least of the three louver margins and highest end array temperature is selected for the detailed study, for the worst cold case will require maximum solar array (electrical as well as thermal) power to maintain temperatures within the spacecraft specifications.

3.2 DETAIL PERFORMANCE

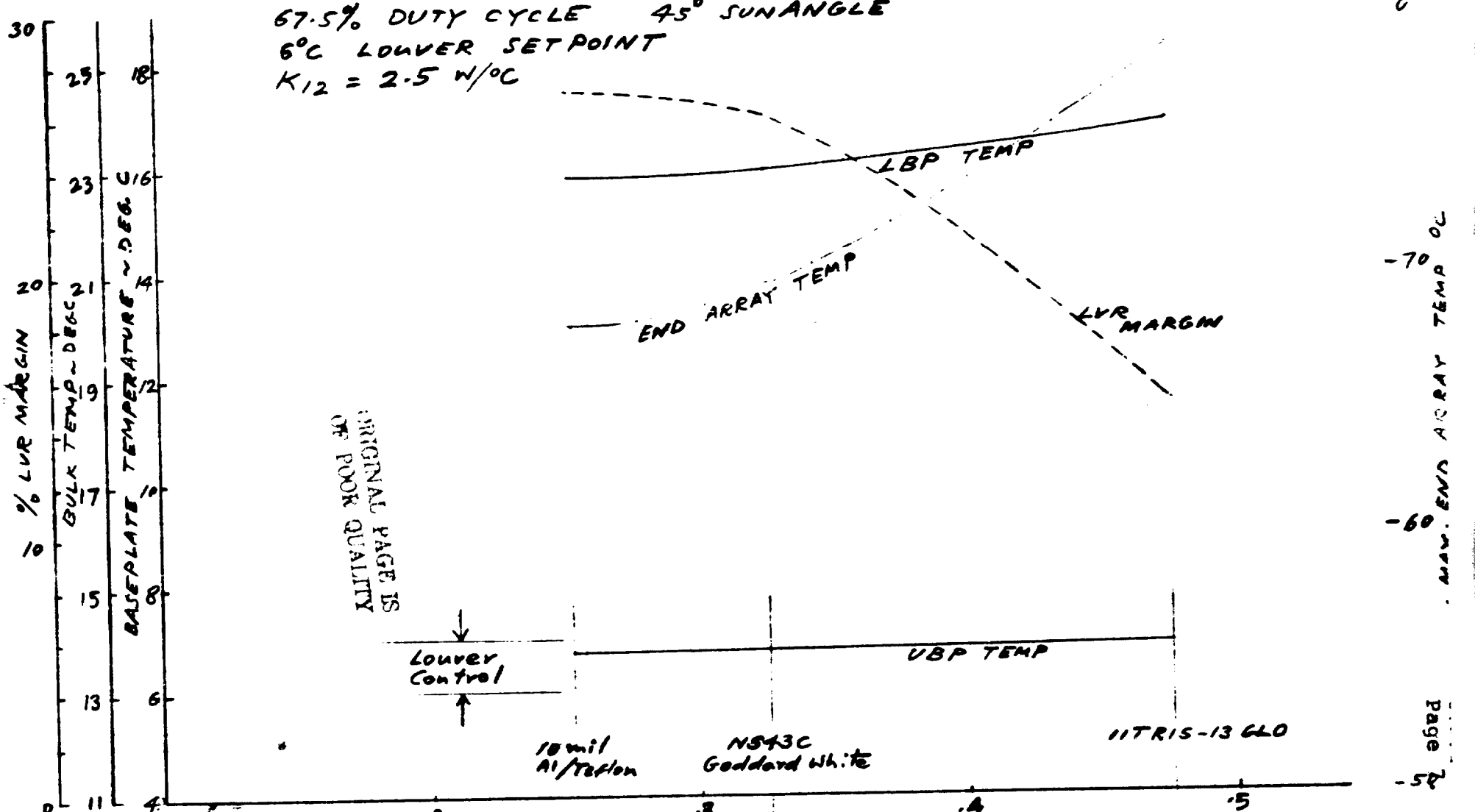
The orbit-average temperatures of upper and lower baseplates as a function of instrument-payload duty cycles, sun angles, and BOL versus EOL variation in thermal properties are plotted in Figures 2 and 3. Data for the 0-percent, 67.5 percent and 100 percent duty cycles are replotted in Figures 4, 5, and 6. Table 4 extracts the data from these figures.

At the high-temperature end, nominal science payload duty cycle of 60 percent (67.5 percent duty cycle of science and playback) and spacecraft in orbital configuration, a maximum EOL temperature of 17°C is obtained on the lower baseplate (see Table 4). This steady-state temperature combined with the thermal transients (± 2°C), gradients across the baseplates (± 2°C) and the uncertainty factor of ± 3°C applied to the analytical predict gives a maximum EOL bulk temperature of 24°C, within the specification limit of 25°C. Note that for additional 4°C, i.e., 28°C of bulk temperature (steady state) up to 100 percent duty cycle can be allowed.

For short duration, this 100 percent duty cycle may be run by manipulating the time-constant of the spacecraft, as well as running earlier 0 percent duty cycle, thereby starting off with a cooler bulk temperature.

FIGURE 1

DE-A UBP AND LBP TEMPERATURES, EOL
67.5% DUTY CYCLE 45° SUNANGLE
6°C LOUVER SETPOINT
K_{12} = 2.5 W/°C



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A conservative assumption will be made here that says that the DE-A spacecraft will go through a zero-degree sun angle after injection prior to achieving final orbital configuration. Since all the science instruments will be off during this maneuver, this 0° sun angle, 0 percent duty cycle represents a worst cold case. Data for this can be obtained from Figure 4, which shows that the worst case cold BOL temperature is $-35.5^{o}C$. Note that this temperature (in fact, all the curves of Figure 4) are obtained with louvers operating logically; that is, if the temperature of the controlled baseplates happen to be below the louver set point, then the computer program automatically closes the louvers. As described earlier, the sunlit end of the louvers are normally commanded close by disabling the ATCE during the orbital configuration to prevent the sun heating up the already hot baseplate. The same sun, however, can be used to warm up the spacecarft when such solar flux becomes desirable.

When the sunlit-end louvers are commanded open by a set point change, the $-35.5^{o}C$ temperature of the upper baseplate warms up to $-13.3^{o}C$. With the spacecraft sensitivity of $.484^{o}C$/watt for 0° BOL curve (see Figure 2), this will require about 17.0 watts of heater power to bring the bulk temperature to $-5^{o}C$ (non-operational limit). This combined with 22.0 watts of continuous load gives a minimum required power of 39 watts. Figure 7 shows total BOL solar array available power during this initial turnaround maneuver. Note that the spacecraft will be turned at the rate of 6°/day. At all times there is some positive heater margin to keep the spacecraft within its specification (non-operational).

In addition, if need be, some battery power is available for short duration to supply the heater power. The time-constant of the spacecraft will also act favorably during this transient maneuver. For those critical items that require higher than $-5^{o}C$, the ATCE heaters may be strategically located in order to gain advantage of the gradient characteristic.

The orbital minimum sun angle will be limited to $\pm 18^{o}$. Again looking at Figure 4 for 0 percent duty cycle, it appears that the 90° sun angle is much colder than the $+18^{o}$. With the sensitivity of $.44\ ^{o}C$/watt, there is plenty of power available at 90° sun angle to keep the spacecraft bulk at $0^{o}C$, within the specification.

Summarizing, this configuration has satisfied the specification limits of $25^{o}C$ to $0^{o}C$ (operational) on the bulk basis, and $-5^{o}C$ (non-operational) during the turnaround maneuver. Table 5 summarizes the performance.

FIGURE 2

DE-A TEMPERATURE RESPONSE VS. SCIENCE & PB PAYLOAD FOR UPPER BASEPLATE (NODE 1) WITH NO ATCE HEATER POWER.

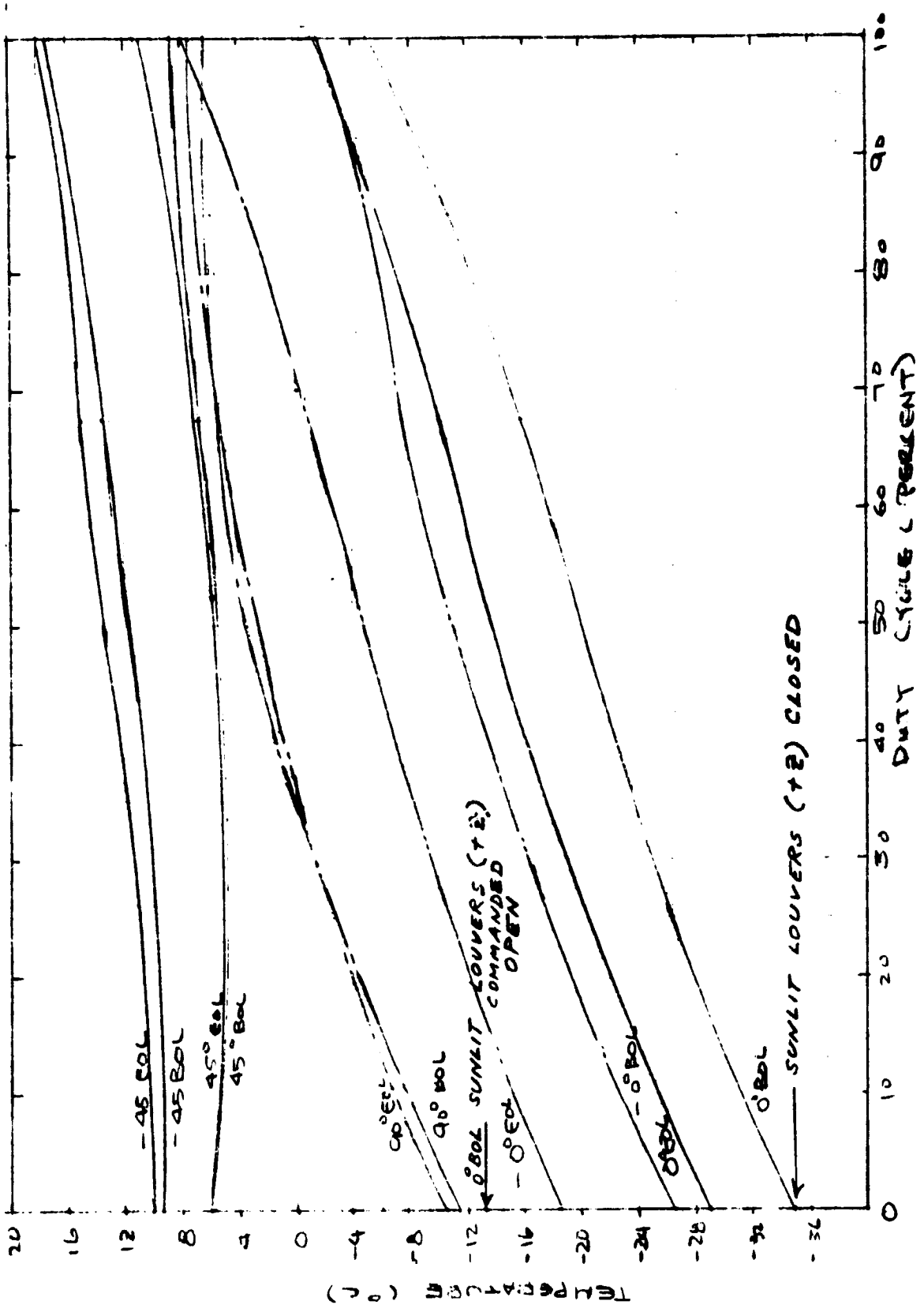


FIGURE 3

DE-A TEMPERATURE RESPONSE VS. SCIENCE +/- PB PAYLOAD FOR LOWER BASEPLATE NODE 2. NO ATCE HEATER POWER.

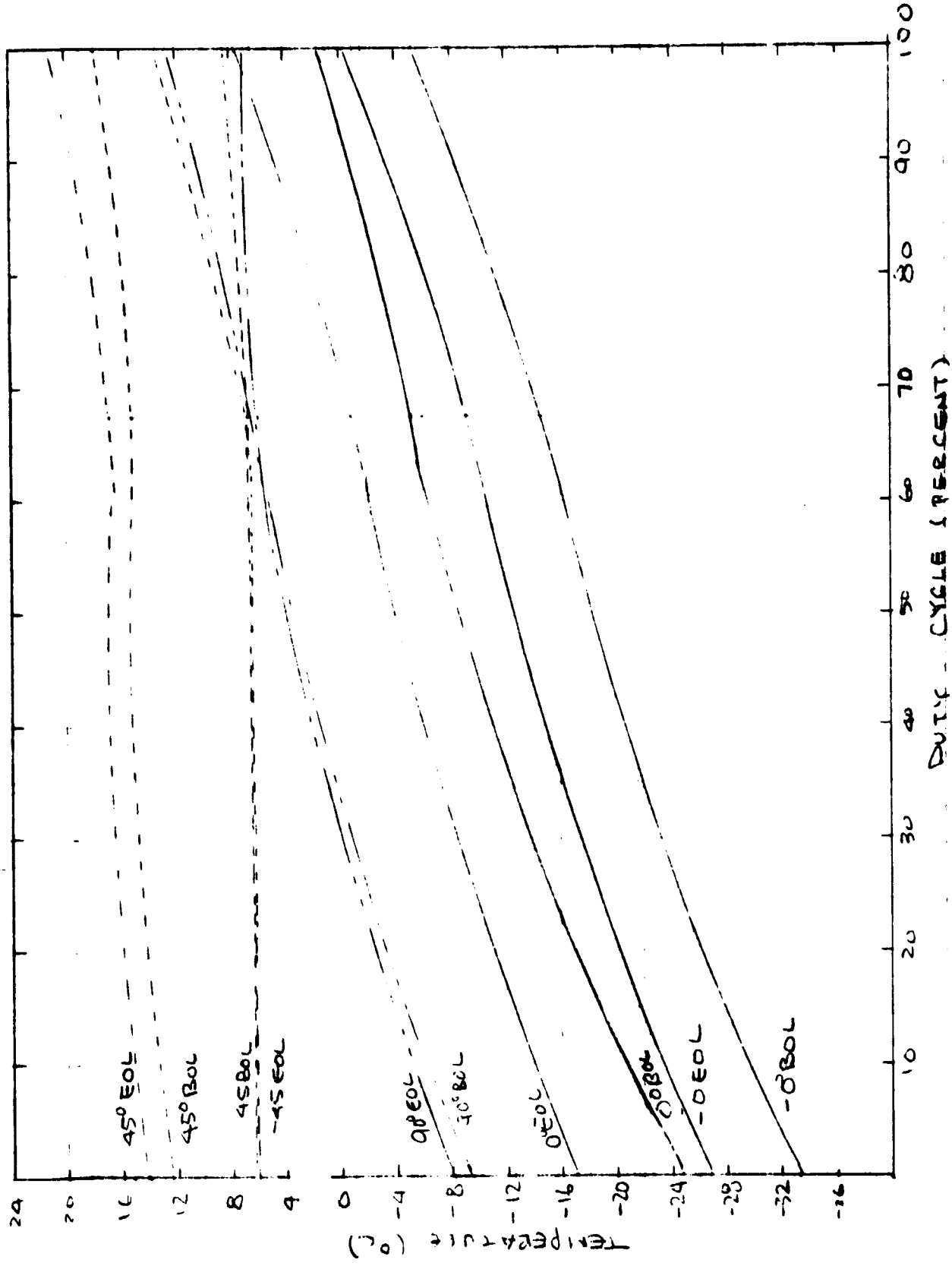


FIGURE 4

DE-A UPPER AND LOWER BASE PLATE TEMPERATURES (BOL & EOL) VS. SUN ANGLE AT 0% DUTY CYCLE.

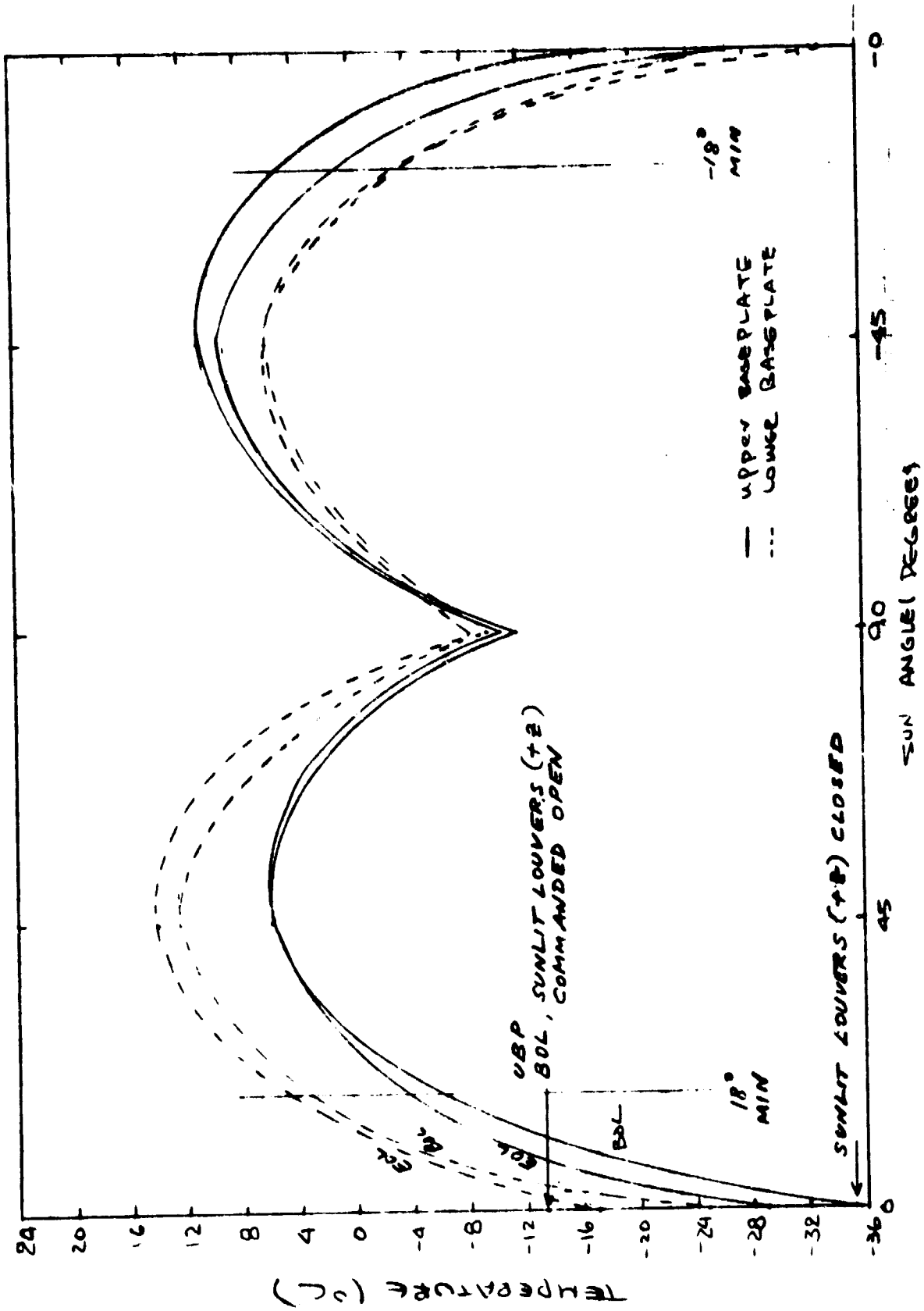


FIGURE 5

DE-A UPPER AND LOWER BASEPLATE TEMPERATURES (BOL & EOL) VS. SUN ANGLE AT 67.5% DUTY CYCLE.

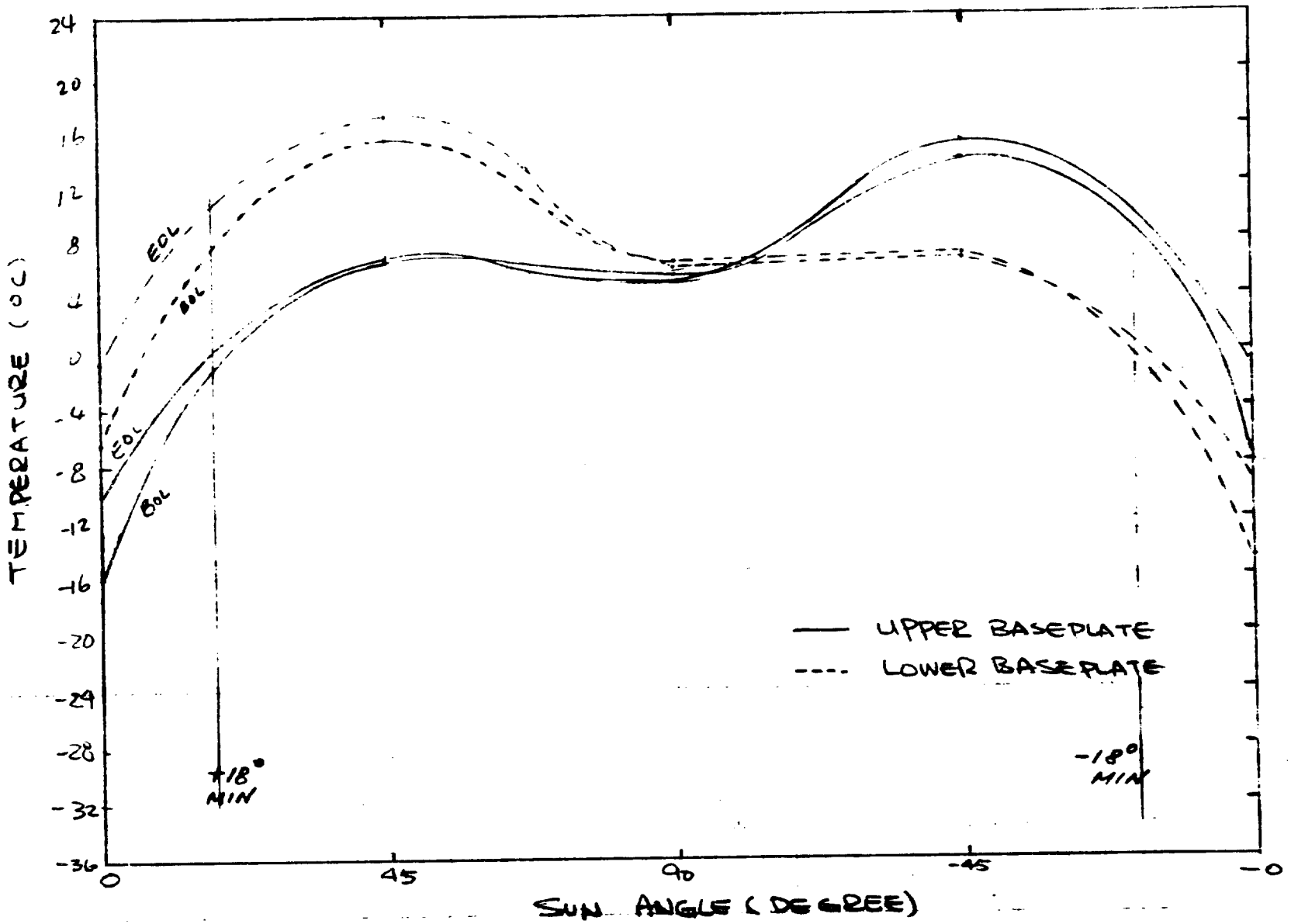


FIGURE 6

DE-A UPPER AND LOWER BASEPLATE TEMPERATURES (BOL & EOL) VS. SUN ANGLE AT 100% DUTY CYCLE.

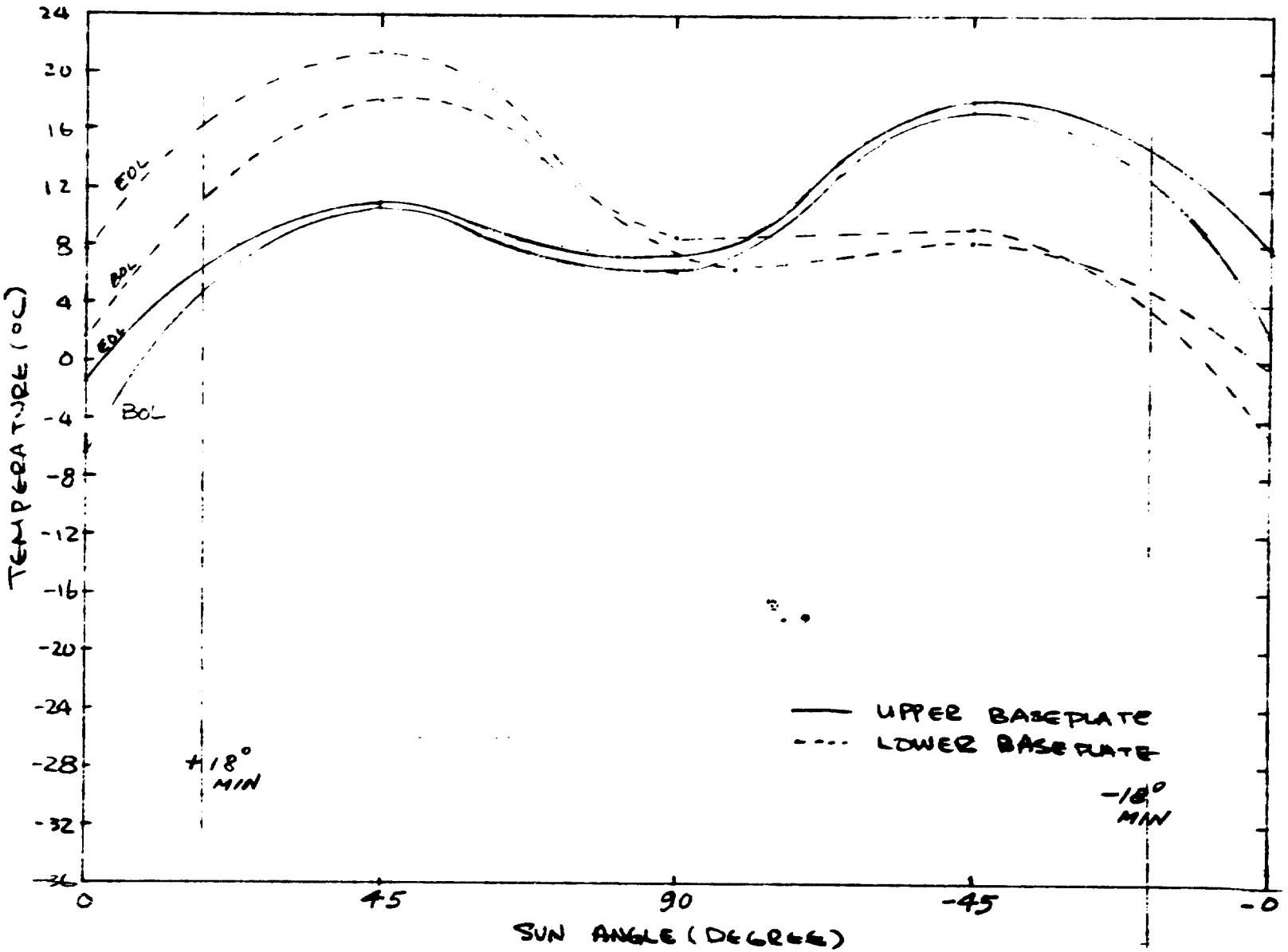
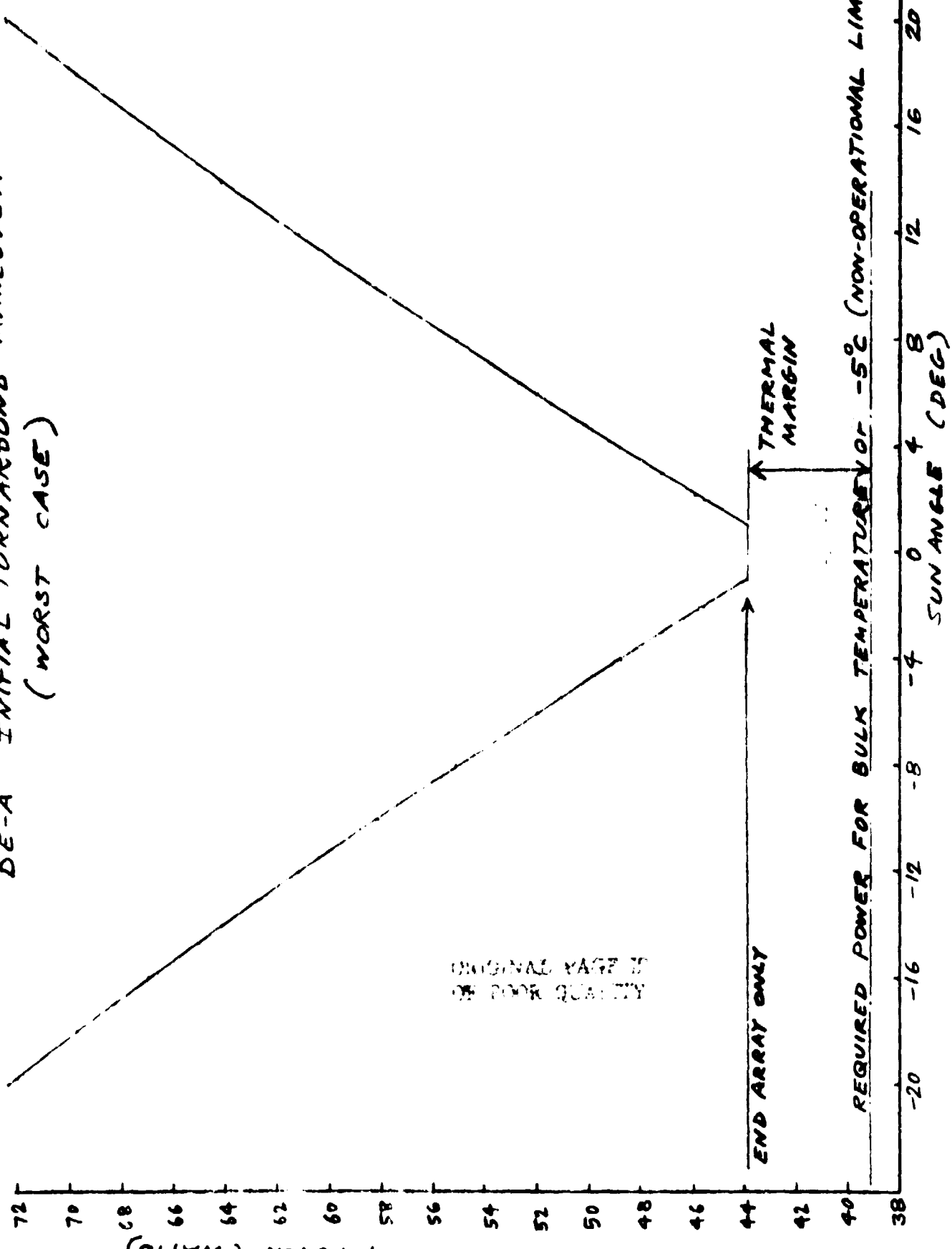


TABLE 4. DE-A Thermal Performance: Final Configuration Orbit-Average Steady-State Temperature Predictions

CASE	DESCRIPTION	DUTY CYCLE OF SCIENCE PAYLOAD	SUN ANGLE (DEG)	TEMPERATURE PREDICTIONS WITHOUT ATCE HEATER POWER (°C)				COMMENTS	THERMAL MARGIN	REFERENCE
				UPPER BASEPLATE		LOWER BASEPLATE				
				BOL	EOL	BOL	EOL			
HOT CASE	NOMINAL POWER DISSIPATION: OPERATIONAL SPECIFICATION LIMITS FOR THE SCIENCE PAYLOAD	60 PERCENT	18	-1.0	0.0	7.5	10.5	Thermal transients (±2°C), thermal gradients (±2°C) and uncertainty factor (±3°C) are applied to maximum EOL temperature prediction of 17°C to arrive at 24°C on the lower baseplate; within specification limit of 25°C.	15% ON LOUVER	FIGURE 4 AND FIGURE 1
			45	6.4	6.8	15.2	17.0			
			90	5.5	5.8	6.0	6.4			
			-45	13.6	15.0	6.5	7.0			
			-18	-0.5	0.5	8.5	9.5			
COLD CASE	INJECTION: PRIOR TO FINAL ON-ORBIT CONFIGURATION: NON-OPERATIONAL SPECIFICATION LIMITS FOR THE SCIENCE PAYLOAD	0 PERCENT	0	-35.5	-29.0	-25.0	-16.0	With sunlit end louvers closed		FIGURE 4
			0	-13.3	-	.7	-	By commanding sunlit-end louvers open, allows the lower baseplate to be coupled to the hot bottom end array bringing upper baseplate to -13.3°C. With spacecraft sensitivity of .484°C/watt, this requires about 17.0 watts of heater power to bring the upper baseplate to -5°C. (Non-operational specification limit). Note that the lower baseplate at +7°C does not require any additional heat.	5 WATTS ON HEATERS	FIGURE 2 AND FIGURE 7
	ORBITAL CONFIGURATION	0 PERCENT	18	-6.0	-4.0	3.2	4.5	ATCE heaters will keep baseplates above 0°C	Plenty heater margin	FIGURE 7
			90	-11.6	-10.4	-9.6	-8.4	" " "		
			-18	1.0	5.2	-3.4	-3.0	" " "		

FIGURE 7

DE-A INITIAL TURNAROUND MANEUVER
(WORST CASE)



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3.3 Duty Cycle Variations

Figure 8 shows DE-A science and playback payload duty cycles as a function of sun angle for the specification temperature of 25°C for BOL & EOL variation. These plots have been generated utilizing data from Figures 2 and 3 and include the thermal transients, gradients and the uncertainty factor. Also plotted on this figure are the duty cycles, BOL and EOL as determined by the available power as a function of sun angle. The two, temperature limited and power limited, provide a composite duty cycle curve, also shown in Figure 8.

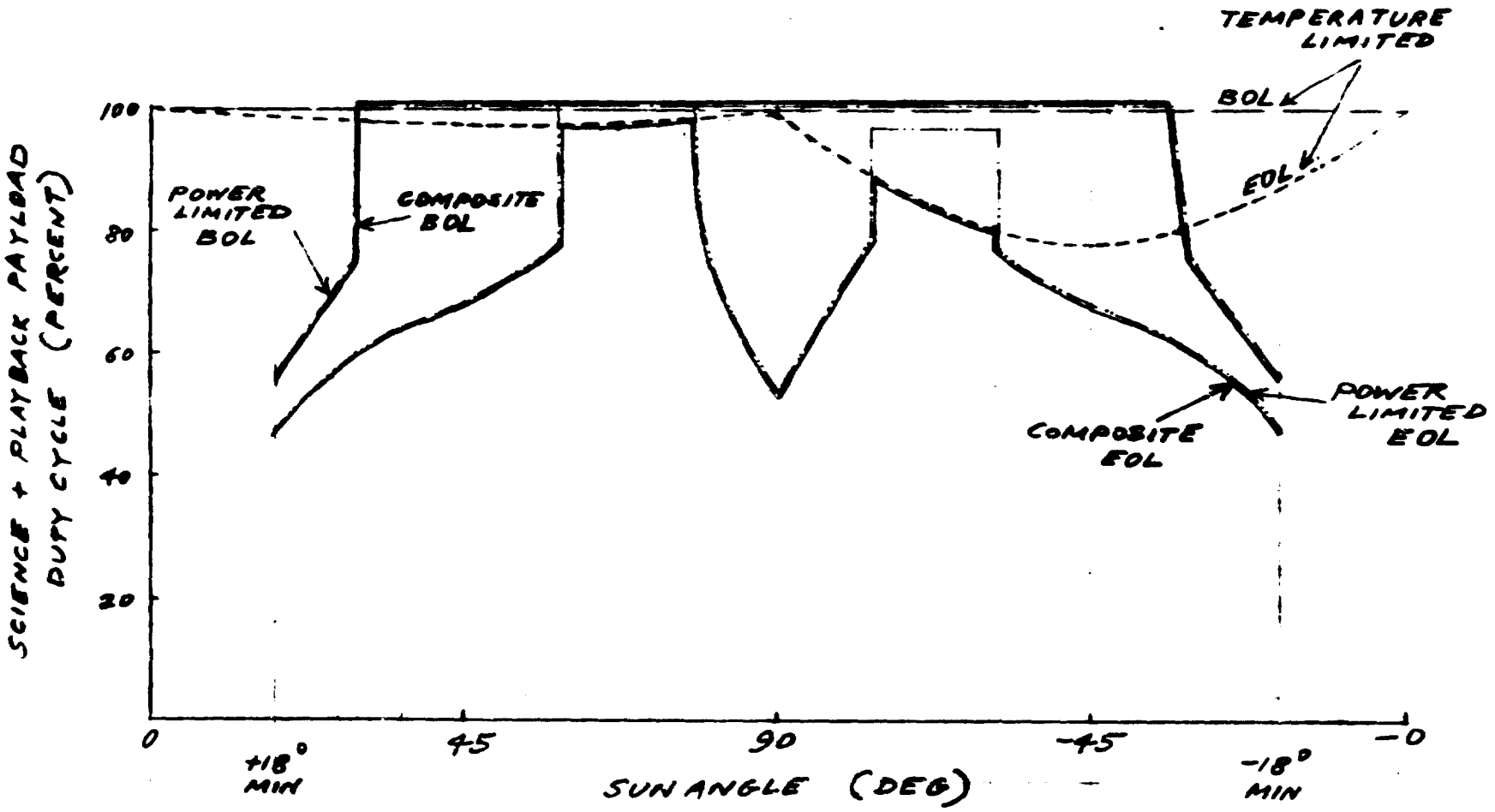
3.4 Solar Array Thermal Performance

The end solar arrays have been looked at in considerable design detail (Tables 1 through 3). Lowering their temperature has enabled the spacecraft bulk temperatures to be within specification, without any cutouts for the ATC's. The orbit-average temperatures of the end array for the 67.5% duty cycles are plotted in Figure 9.

The orbit average temperature of side array as function of sun angle is shown in Figure 10, which hasn't changed much from original design note 3.2.2-003-DN. Both end and side array temperatures for specific sun angles are extracted from these figures and tabulated in Table 5.

FIGURE 8

DE-A DUTY CYCLE PERFORMANCE VS SUNANGLE
FOR 25°C BULK SPECIFICATION TEMPERATURE
COMPOSITE TEMPERATURE AND POWER LIMITED



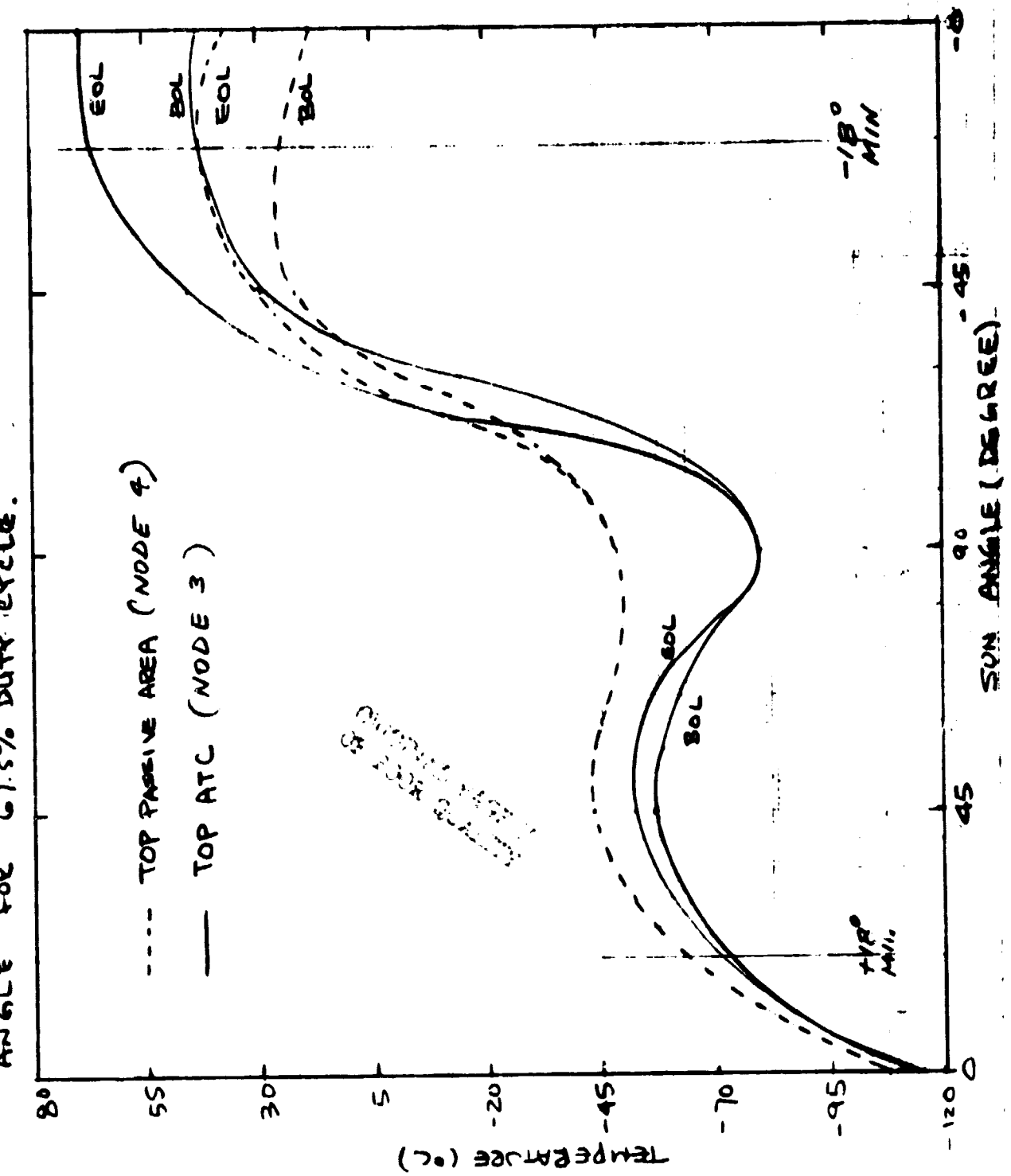


FIGURE 9
DE-A TOP ATC and TOP PASSIVE AREA TEMPERATURES VS. SUN ANGLE FOR 67.5% DUTY CYCLE.

FIGURE 10

MEAN TEMPERATURE OF DE-A UPPER SIDE ARRAY (NODES 10, 11, 12, 13) VS SUN ANGLE FOR 67.5% DUTY CYCLE.

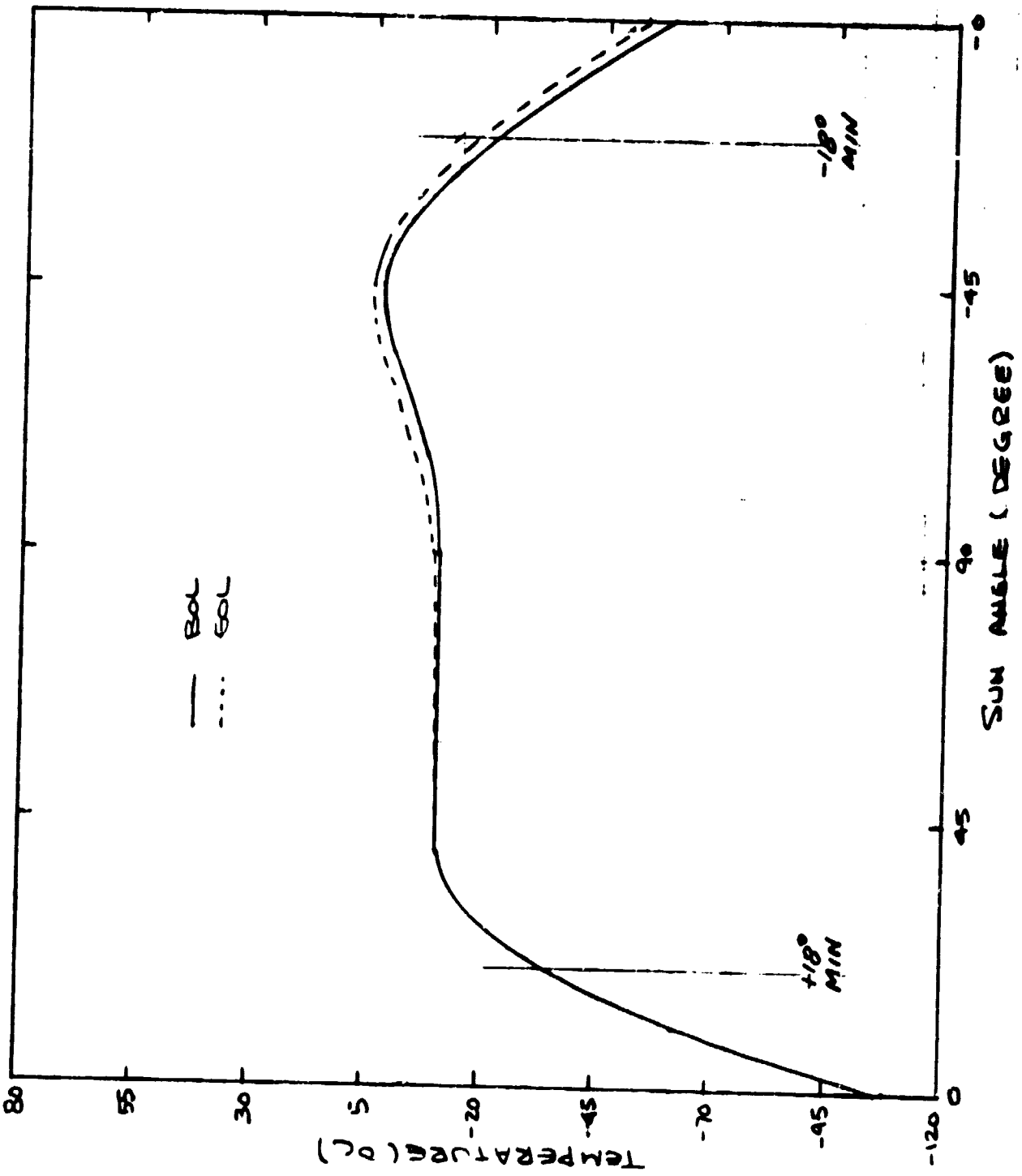


Table 5. Solar Array Temperature for Orbit-Average Steady-State at 67.5% Duty Cycle of Science and Playback Payload

Solar Array	Sun Angle (degree)	Orbit-Average Temperature (^{o}C)		Reference
		BOL	EOL	
Top-ATC of End Solar Array	18	-75	-72	Figure 9
	45	-57	-55	
	90	-80	-80	
	-45	30	45	
	-18	42	67	
Upper Side Array	18	-35	-35	Figure 10
	45	-10	-10	
	90	-10	- 8	
	-45	3	5	
	-18	-21	-16	

4. Discussion

In addition to satisfying the specification temperature limits, following advantages have been realized by this configuration:

1. Since no cutouts will be present in the end panel, this eliminates the need for solar simulation testing of the ATC configuration to verify the design and the thermal model.

2. Failed-open louver case can be handled easily by this configuration, with no solar flux impinging upon any critical equipment causing catastrophic failures.

3. Lowering the temperature of end array increases the solar cells efficiency, thereby reducing the required number of cells. This makes more area available for radiator purposes to further cool the end array. This 'self-feeding' effect is an important parameter that provides some control on the thermal design.

4. It has been discussed earlier that the passive set point of the louver bimetal housing require that the ATC housing be somewhat decoupled from the high end-array temperature. Lowering the end array temperature has made that decoupling design problem easier.

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 3.2.2-006-DN

Title

DE-B Parametric Thermal Study and Performance

Written by: C. Chhatpar	Date October 13, 1978
Approved by: W. Fuldner	Date October 13, 1978
This DN supplements (S), replaces (R) DN Nos. (S) 3.2.2-002-DN ( )	

REVISIONS

Letter	Description	Date	Author

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1. SUMMARY

The DE-B presents less severe thermal conditions than the DE-A, since the variation in external thermal factors from worst-case cold to worst-case hot orbits will be smaller and the spacecraft will be rotated through 180° when the sun crosses the orbit plane to maintain the top of the spacecraft in anti-sun side. Like AE, the active louver control will not be required on the bottom surface.

It is assumed that the similar Active Thermal Control (ATC) configuration as used on the AE spacecraft will be used for this mission, with a 'fine tuning' improvement of performance to be accomplished as the detail design progresses.

2. DESIGN CONFIGURATION

The principal features of the DE-B thermal design are illustrated in Figure 1. This design is similar to that of the Atmosphere Explorer spacecraft.

The top array substrate serves as the principal sink for the internal power dissipation. This surface is on the antisun side of the spacecraft and has the least variation in external thermal factors. It serves to minimize the baseplate-temperature variation with changes in orbital power dissipation. The upper hat will include four 20-inch diameter active-thermal-control louvers, of the same double-blade pinwheel type that was used on Atmosphere Explorer. These will be used to vary the radiative coupling from the upper baseplate equipment to cold space through cutouts in that substrate. Controlled radiation couplings from the side-array surfaces to the internal equipment are accomplished through the use of black paint and gold tape applied to the inside of the side arrays. The external thermal factors on these array surfaces have a direct relation to internal power dissipation and tend to magnify the temperature differences between worst-case hot and worst-case cold conditions.

The power dissipation from the internal equipment is distributed unequally between the upper and lower baseplates. The lower baseplate will carry about 1/3 of the total power dissipation. This compensates for the smaller coupling between this baseplate and the top sink and equalizes the temperature levels for all internal equipment.

ATCE controlled heaters are provided on the upper and lower baseplates to prevent equipment temperatures from falling below the allowable minimum values during orbits when the instruments are not operated.

The shunt-limiter components are distributed over both the end and side arrays. The resistance section of the limiter is spread uniformly over the entire array surface using a serpentine resistance-wire layout. The transistors are placed on corner brackets between the end and side arrays to distribute the power in accordance with array temperatures. The relatively uniform distribution of power over the array surfaces minimizes the effect of shunt-limiter dissipation on internal equipment and array temperatures.

Simplified thermal model data for the DE-B spacecraft is described in DE design note 3.2.2-002-DN, which also describes variable parameters that depend on louver position. Table 1 provides variable parameters for this configuration. Appendix A contains a representative printout of computer program for a 50% duty cycle of science aldn playback payload.

3. THERMAL PERFORMANCE

Thermal performance of the baseline configuration as described in the DE Technical Proposal NO. 102658-C, June 30, 1978 dictated maximum EOL bulk temperature of 30°C, out of temperature specification limit of 25°C. The minimum BOL bulk temperature of 0°C for the orbital configuration was shown to meet the temperature specification limit.

As a result, parametric study was carried out to evaluate the effect of active louver setpoint on the maximum bulk temperature. Again, it should be noted that the analytical predictions have to be corrected for the thermal transients ($\pm 2^{\circ}C$), thermal gradients ($+2^{\circ}C$) across the baseplates and the uncertainty factor of $\pm 3^{\circ}C$, applied to the simplified steady-state temperature of the lower baseplate. Therefore, for the maximum bulk temperature specification limit of 25°C, the analytical prediction has to be below 18°C.

Orbit-average temperatures of lower and upper baseplates as function of louver setpoints, sun angles and BOL versus EOL variations, in thermal properties are plotted in Figure 2 and 3, respectively, for 50% duty cycle of science and playback payload. Figure 2 shows that the maximum EOL lower baseplate temperature for a 6°C louver setpoint is 17.8°C which corresponds to 24.8°C on bulk basis, below the 25°C specification limit. Figure 3 shows that both lower setpoints keep the upper baseplate under louver control for sun angles of 30° and 90°, but 0° sun angle is clearly out of the louver control range, requiring some heater power for BOL condition to bring the upper baseplate to 0°C.

TABLE 1 VARIABLE PARAMETRIC VALUES FOR THERMAL MODEL

FROM MODE	TO SINK	EXTERNAL RADIATION COUPLING(in^2) LOUVERS FULLY CLOSED	EXTERNAL RADIATION COUPLING(in^2) LOUVERS FULLY OPEN (See Note 3)	COMMENTS (SEE NOTE 1)
1	17	0.0	569.0	Louver SetPoint = 12°C Baseline Configuration.
1	17	0.0	569.0	Louver Set Point = 6°C (Revised Configuration)
1	2	Conductive Coupling (WATTS/°C) 2.5		This value is increased from that used in baseline configuration of the Proposal of 1.25 Watts/°C resulting in about 6.0 lbs. weight penalty.

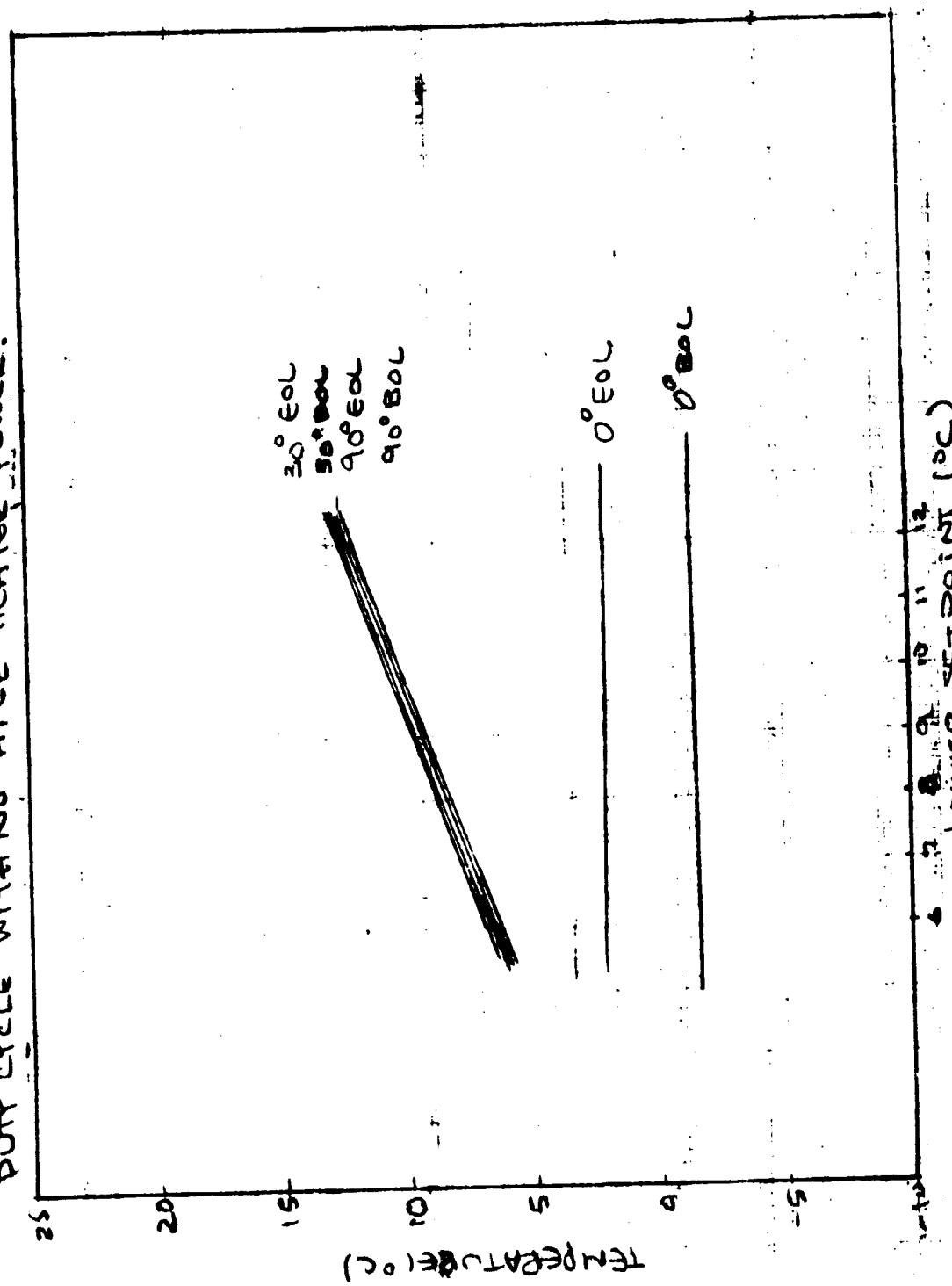
NOTE: 1-Fully closed values are applicable for upper baseplate temperatures below setpoint. Fully open louver values for temperature 1°C higher than the setpoint. Program computes proportional values between these two temperatures.

2-Sun angle for this spacecraft varies from 0° to 90°.

3-The value considers blockage of space by MWA.

FIGURE 3

DEPENDENCE OF DE-B UPPER BASEPLATE TEMPERATURE ON THE ATL LOUVER SET POINT FOR 50% SCIENCE AND PLAYBACK DUTY CYCLE WITH NO ATCE HEATER POWER.



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FIGURE 2

DEPENDENCE OF PE-B LOWER BASEPLATE TEMPERATURE ON THE ATC LOUVER SET POINT FOR 30% SCIENCE AND PAYBACK DUTY CYCLE WITH NO ATLE HEAT POWER.

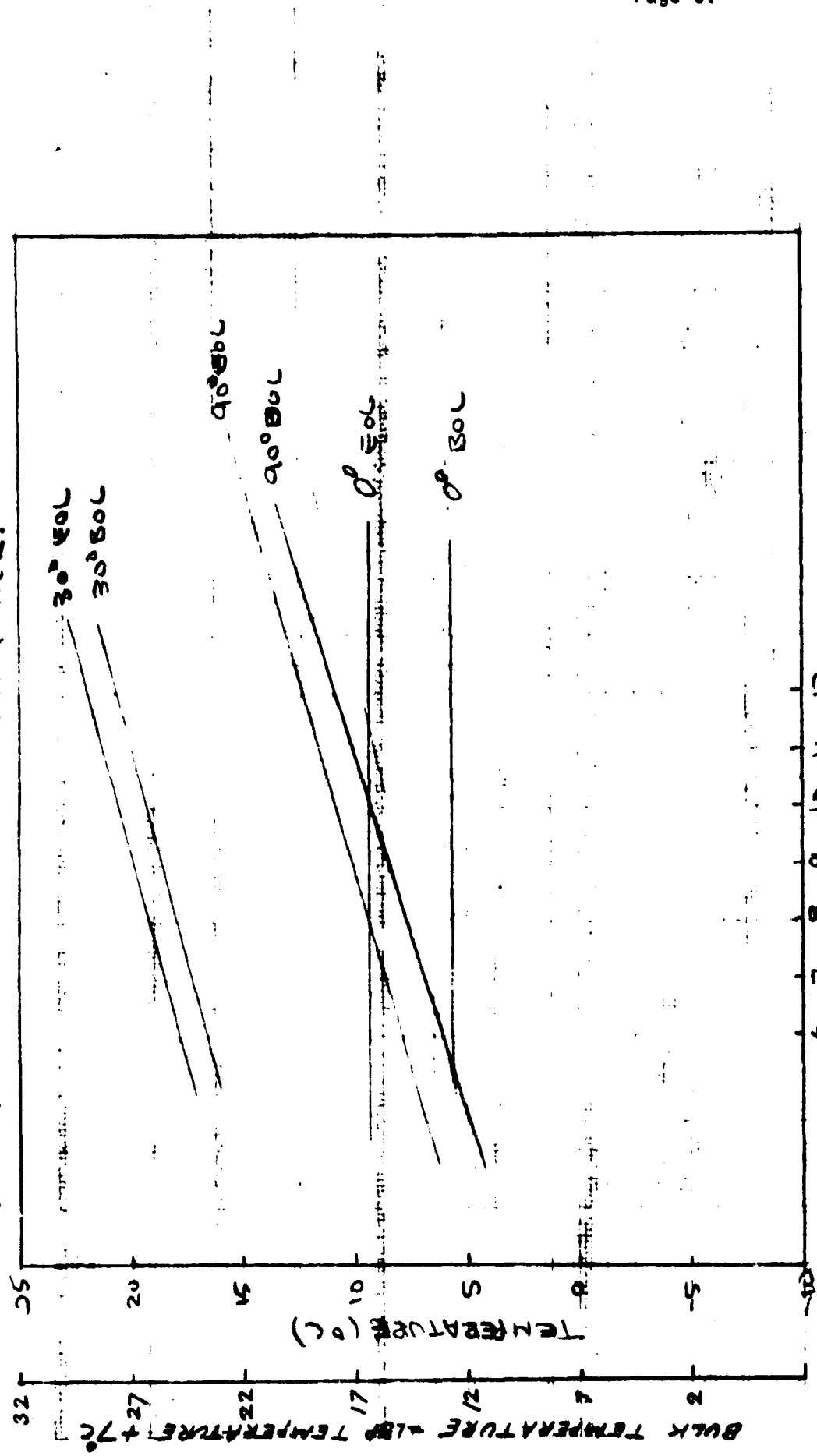
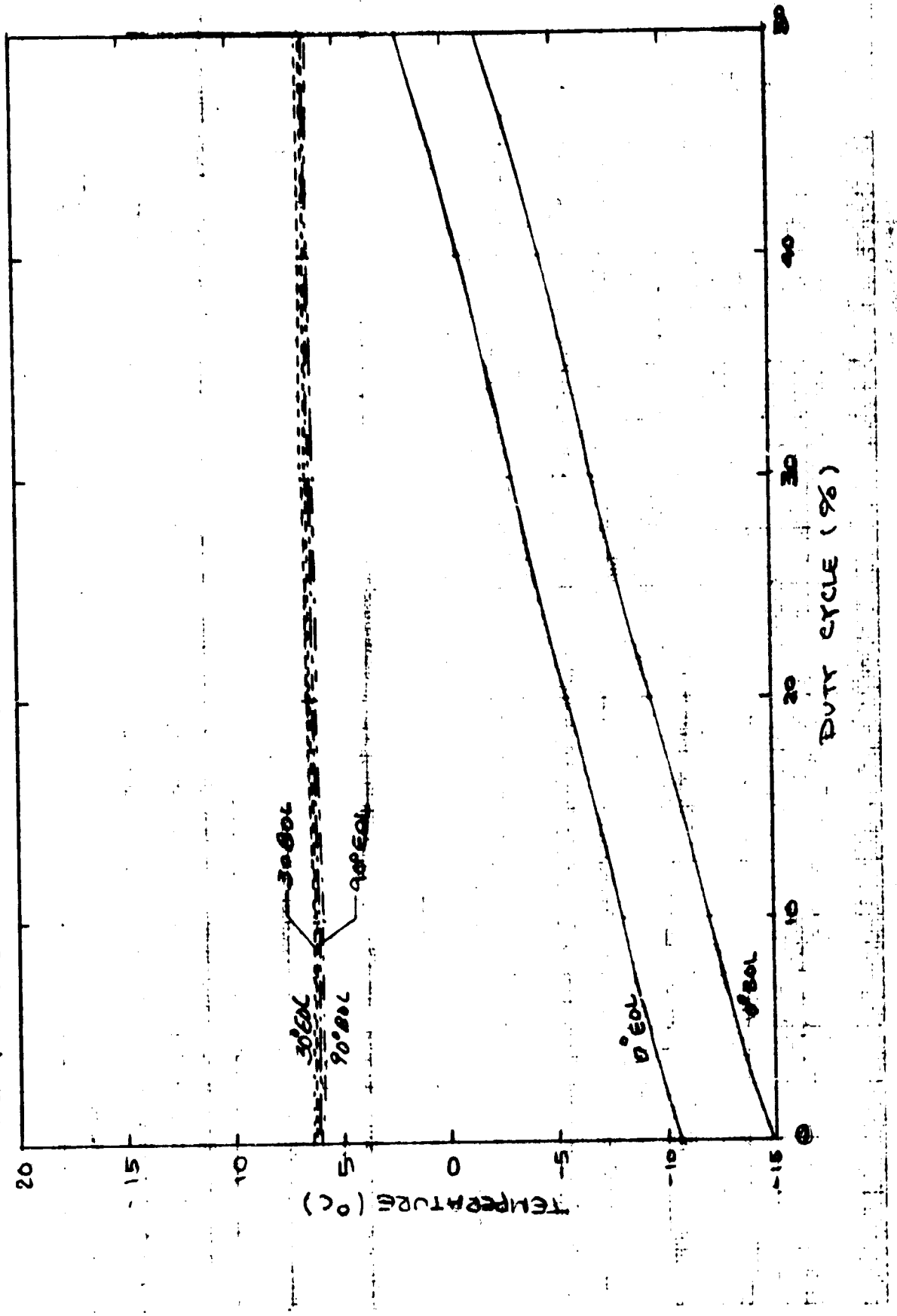


FIGURE 4

DE-B UPPER BASEPLATE TEMPERATURE AS A FUNCTION OF DUTY CYCLE FOR SCIENCE AND PLAYBACK PAYLOAD (NO ATCE POWER).



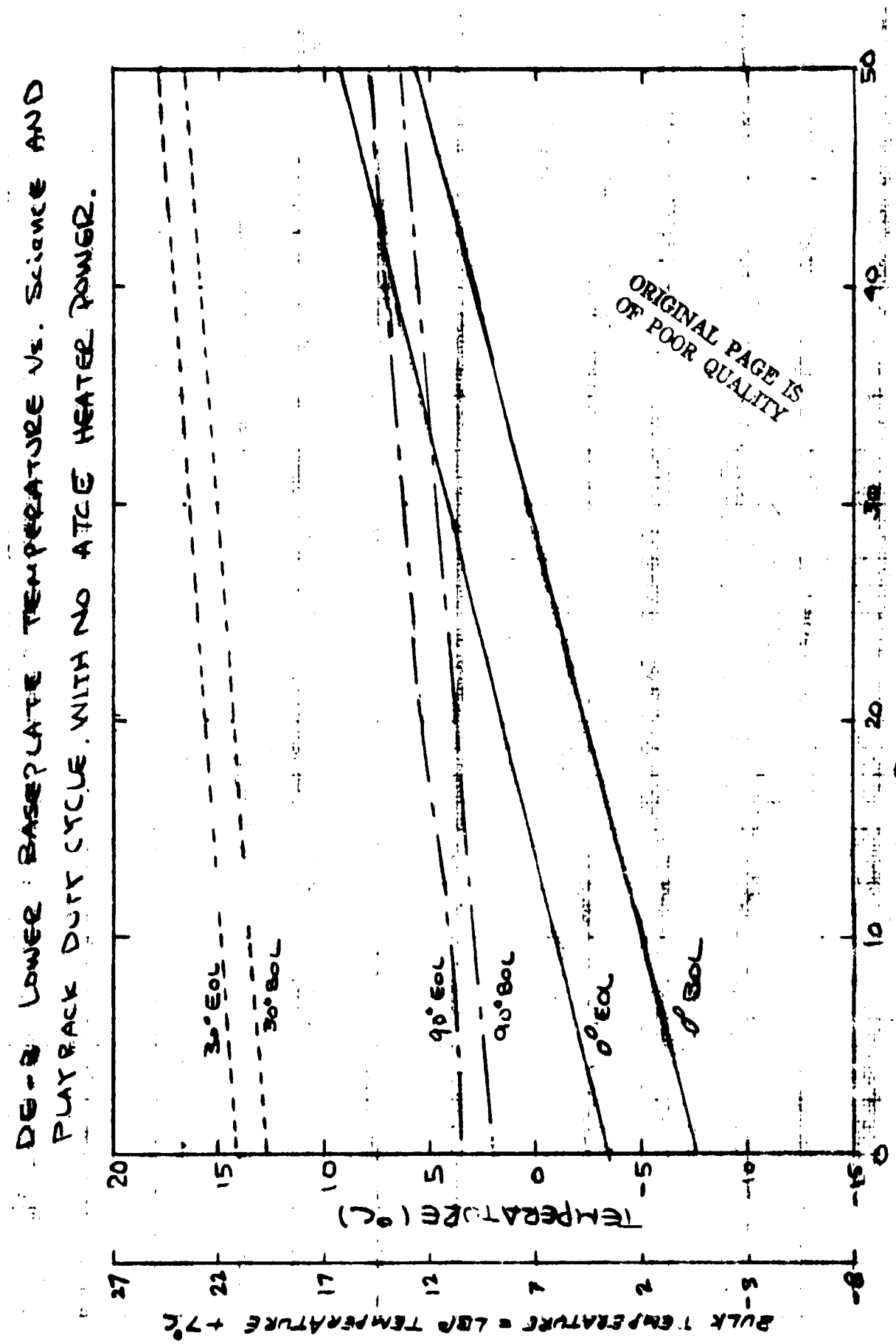


FIGURE 5

DE-B LOWER BASEPLATE TEMPERATURE Vs. SCIENCE AND PLAYBACK DUTY CYCLE WITH NO ATCE HEATER POWER.

The orbit-average temperatures of upper and lower baseplates as function of instrument-payload duty cycles, sun angles, and BOL versus EOL variations in thermal properties are plotted in Figures 4 and 5. Data for the 0-percent and 50 percent cycles of the science payload are replotted in Figures 6 & 7. Table 2 extracts the data from these two figures and shows that for 0-degree sun angle and 0-percent duty cycle (representing injection into orbit, experiments-off condition), the upper baseplate reaches the cold temperature of -14.7°C if no heaters are present. The ATCE control provides for the heater power when the thermistor senses the upper baseplate temperature below 1°C. Figures 4 and 5 show that the spacecraft temperature sensitivity to power dissipation is about .412°C/watt. This will require about 36 watts of heater power to maintain the upper baseplate at 0°C, for 0-percent duty cycle on the Science payload with the spacecraft at 0-degree sun angle. Assuming a 10 to 12 percent increase in solar array power from the EOL power value of 75.2 watts gives about 83.5 watts of total EOL available power. Since the required power, including continuous load, is 70 watts, there is adequate power margin to maintain spacecraft above 0°C during the initial injection. Figure 6 also shows that for the minimum sun angle of 18°, with the upper and lower baseplates are above 0°C, not requiring any heater power during nominal orbital configuration.

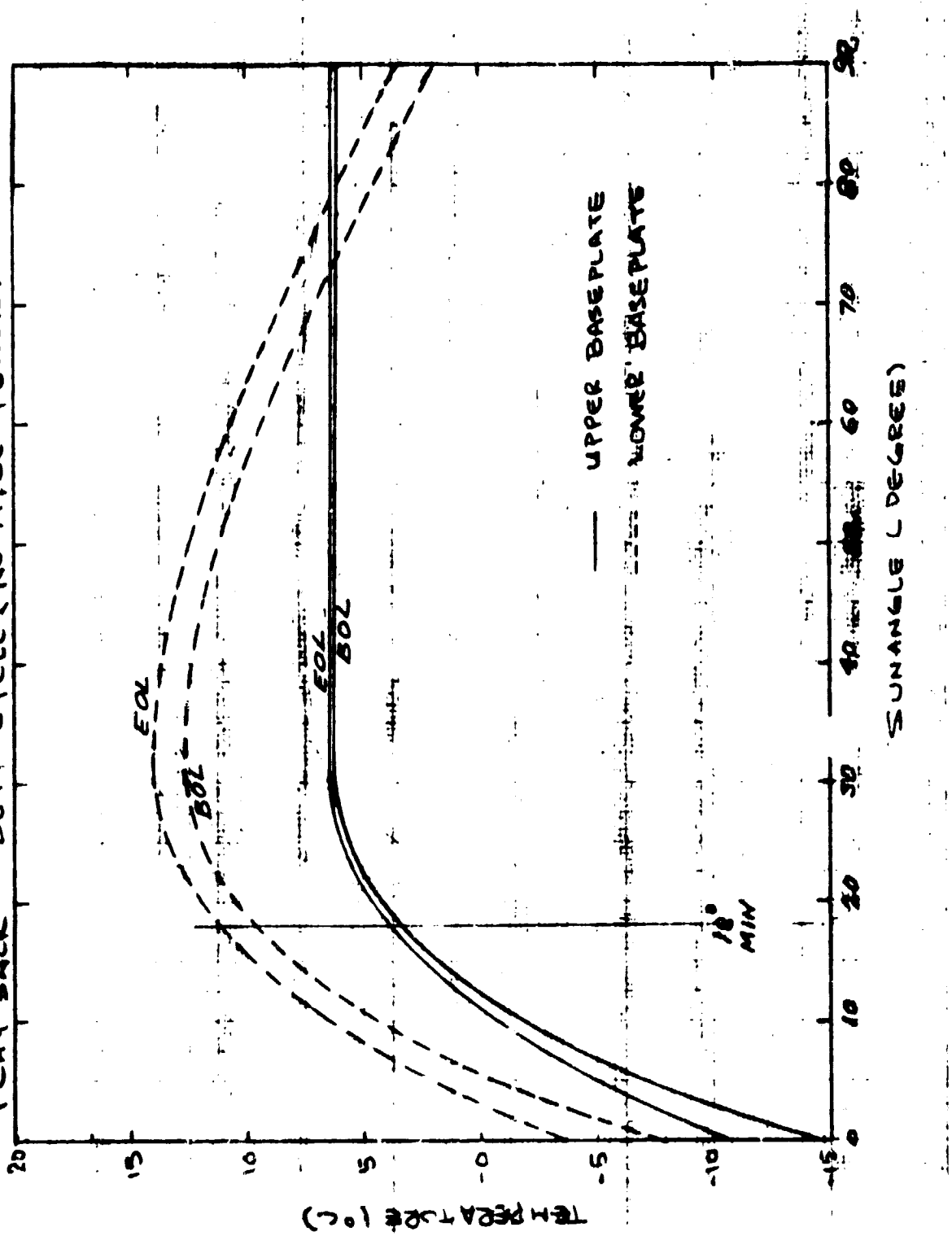
Table 2 shows that the maximum EOL upper baseplate temperature is 6.71°C, which correspond to a lower margin of about 29%. This margin can be applied towards the louvers failure analysis or lowering the side end and array temperature by coupling them more to the baseplates.

TABLE 2. DE-B THERMAL PERFORMANCE: ORBIT-AVERAGE STEADY-STATE TEMPERATURE PREDICTIONS

Reference	Duty Cycle of Science Payload (Percent)	Description	Sun Angle (degrees)	Temperature Predictions Without ATCE Heater (°C)				Comments
				Upper Baseplate		Lower Baseplate		
				BOL	EOL	BOL	EOL	
Figure 6	0	Injection, prior to Final Orbital Configuration	0	-14.7	-10.7	-7.8	-3.5	With spacecraft sensitivity of 4.2 C/watt, this will require about 38.0 watts of heater power to bring upper baseplate temperature to 0°C.
		Non-operational for the Science Payload	90	6.0	6.2	2.0	3.5	
Figure 7	50	Orbital Configuration	18	4.8	5.7	14.5	16.0	Thermal gradient transients and uncertainty factors are applied to the the maximum temperature of 17.8°C of lower baseplate to arrive at upper bulk temp = 24.8°C.
		Nominal Power Distribution	30	6.6	6.71	16.6	17.8	
		Operational for the Science Payload	90	6.32	6.47	6.44	7.9	

FIGURE 6

DE-8 UPPER AND LOWER BASEPLATES TEMPERATURE AS A FUNCTION OF SUNANGLE FOR 0% SCIENCE AND PLAY BACK DUTY CYCLE (NO ATCE POWER)



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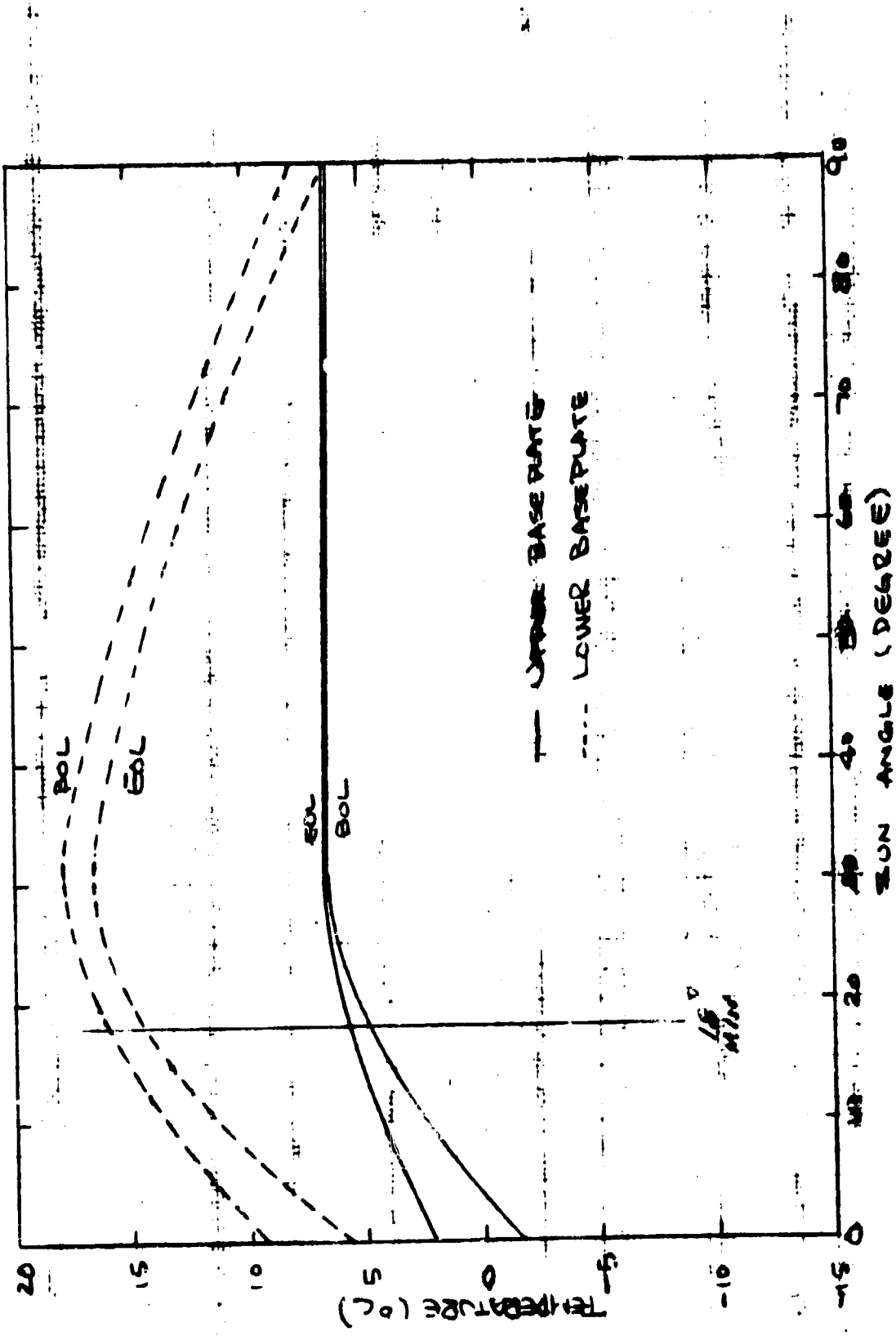

DE-B UPPER AND LOWER BASEPLATE TEMPERATURES VS.
SUN ANGLE FOR 50% SCIENCE AND PLAYBACK DUTY CYCLE
WITH NO ATCE HEATER POWER.
BOL
EOL
EOL
BOL
UPPER BASEPLATE
LOWER BASEPLATE
TEMPERATURE (°C)
SUN ANGLE (DEGREE)
20
15
10
5
0
-5
-10
-15
0
20
40
60
80
90

FIGURE 7

FIGURE 8

DE-8 DUTY CYCLE PERFORMANCE VS SUN ANGLE
FOR ±5°C BULK SPECIFICATION TEMPERATURE
COMPOSITE TEMPERATURE AND POWER LIMITED

C-4

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3.2 Duty Cycle Variations

Figure 8 shows DE-B science and playback payload duty cycles as a function of sun angle for the specification temperature of 25°C for BOL and EOL variation. These plots have been generated by utilizing data from Figures 4 and 5 and extrapolating from Figure 5. They include the thermal transient gradients and the uncertainty factor effects. Also plotted on this figure are the duty cycles, BOL and EOL, as determined by the available power from solar arrays as a function of sun angle. The two, temperature limited and power limited, provide a composite duty cycle curve, also shown in Figure 8.

4. DISCUSSION

It is shown that by lowering the active setpoint of the louver to 6°C and increasing the conductive coupling between the baseplates (to make them same as for DE-A), the upper maximum bulk temperature of 25°C has been achieved. In addition, about 29% additional louver heat dumping capability exists, some of which can be utilized to lower the end and side array temperatures which will ultimately result in a higher minimum duty cycle as dictated by the available power. At the cold end, both during injection as well as for orbital configuration, plenty of heater margin exists to maintain the spacecraft bulk temperature at 0°C.

Table 3 lists temperature specifications for instruments and selected components, which are all above the upper bulk temperature of 25°C. Those items with 0°C minimum operational limit may be provided with strategically located ATCE controlled heaters:

TABLE 3 DE-B THERMAL SPECIFICATIONS

ITEM		Allowable Temperature Limit Non-Operational ^0C MIN	MAX	Operational ^0C MIN	MAX	COMMENTS
MAG	Electronics	-25	50	-10	40	
	Boom Heat Sink	-60	60	-40	40	
RPA		-30	75	-20	60	
WATS		-40	60	-10	40	
LANG		TBS	TBS	TBS	TBS	
VEFI	Electronics & Preamplifier	-30	60	0	40	
	Tubular Antenna	-20	40	0	30	External to spacecraft.
FPI		-20	60	-10	30	Prefers smaller transients
IDM		-30	75	-20	60	
LAPI		-30	40	0	35	
NACS		-40	60	-10	40	
MWA		-20	50	-5	40	
SCAN PLATFORM		-20	50	-5	40	
BATTERY		-5	40	0	40	Maximum operational limit is applicable for limited DOD and cycles only
TR		-17	35	-17	35	
TRANSPONDER		-25	70	-15	50	

<u>NOTES</u>: 1. All limits are applicable on unit mounting interface.
2. Temperature limits of all GFE items have been obtained from the latest UNDOCS information.

APPENDIX A

COMPUTER PRINTOUT OF STEADY-STATE TEMPERATURE FOR A REPRESENTATIVE DUTY CYCLE FOR DE-B SPACECRAFT

Table A-1. Look-up Table of Radiation Coupling from Node 1 to Sink 17*

```
----DYNAMIC EXPLORER THERMAL MODEL,21 NODE, 180DEGREE SUN ANGLE,BOL------
       1 4 1                                                        3
      -100.0000     6.0000     7.0000   100.0000     0.0         0.0       0.0       0.0       0.0    1
         0.0        0.0      569.0000   569.0000     0.0         0.0       0.0       0.0       0.0    2
  0.0       0.0
569.0000**********
  0.0     565.0003
```

*Corresponds to louver active set point of $12^{o}C$ (louver start to open) to $13^{o}C$ (louver fully open). Varies radiation coupling as a function of upper baseplate temperature.

Table A-2. Nodal Radiation Couplings (w/in^2)

INPUT MATRIX VALUES FOR RIJ

I	J	RIJ	I	J	RIJ	I	J	RIJ	I	J	RIJ
1	2	787.600000	1	3	59.000000	1	4	44.899994	1	10	132.500000
1	11	132.500004	1	12	132.500000	1	13	132.500000	1	14	7.700000
1	15	7.650000	1	16	7.650000	1	17	7.650000	1	18	3.600000
1	19	3.600000	1	20	3.600000	1	21	3.600000	2	6	44.100006
2	10	6.300000	2	11	6.900000	2	12	3.900000	2	13	6.900000
2	14	75.000000	2	15	75.000000	2	16	75.000000	2	17	75.000000
2	18	0.400000	2	19	0.400000	2	20	0.400000	2	21	0.400000
3	10	4.175000	3	11	4.175000	3	12	4.175000	3	13	4.175000
4	10	1.500000	4	11	1.500000	4	12	1.500000	4	13	1.500000
5	7	236.500000	5	6	164.320007	6	7	3.960000	6	8	29.809998
6	14	1.500000	6	15	1.500000	6	16	1.500000	6	17	1.500000
7	8	373.500000	7	9	6.200000	7	14	0.200000	7	15	0.200000
7	16	0.200000	7	17	0.200000	8	9	29.500000			

Table A-3. Nodal Conductive Couplings (w/^{o}C)

INPUT MATRIX VALUES FOR KIJ											
1	2	2.500000	1	10	0.028000	1	11	0.028000	1	12	0.028000
1	13	0.024000	2	7	1.260000	2	14	0.024000	2	15	0.024000
2	16	0.024000	2	17	0.024000	3	4	0.650000	4	10	0.100000
4	11	0.100000	4	12	0.100000	4	13	0.100000	5	6	0.650000
5	7	1.241304	5	8	7.600000	6	7	0.100000	6	14	0.500000
6	15	0.500000	6	16	0.500000	6	17	0.500000	7	8	0.200000
7	9	0.052000	10	11	0.040000	10	13	0.040000	10	14	0.050000
11	12	0.040000	11	15	0.050000	12	13	0.040000	12	20	0.050000
13	21	0.090000	14	15	0.040000	14	17	0.040000	14	18	0.090000
15	16	0.040000	15	19	0.090000	16	17	0.040000	16	20	0.050000
17	21	0.050000	18	19	0.027000	18	21	0.027000	19	20	0.027000
20	21	0.027000									

Table A-4. Radiation Coupling from Node to Sink (in^{2})

INPUT MATRIX VALUES FOR KIS											
1	15	8.234000	1	17	-1.001000 **	2	16	0.010000	3	1	686.479980
4	1	537.600098	6	10	874.800049	7	17	9.500000	8	17	352.000000
9	17	10.000000	10	2	662.000000	11	3	662.000000	12	4	662.000000
13	5	662.000000	14	6	544.000000	15	7	544.000000	16	8	544.000000
17	9	544.000000	18	11	33.500000	19	12	33.500000	20	13	33.500000
21	14	33.500000									

**Refers to look-up Table A-1.

Table A-5. Thermal Sink Values for Sun Angle = 0° (watts/in^{2})

RESULTANT MATRIX OF 4 ITERATION FOR I											
1	0.0370	2	0.0910	3	0.0880	4	0.0030	5	0.0070	6	0.0910
7	0.0880	8	0.0030	9	0.0070	10	0.0560	11	0.0970	12	0.0880
13	0.0030	14	0.0120	15	0.0450	16	0.0210	17	0.0		

Table A-6. Temperature Distribution (°C) For Various Sun Angles; 50% Duty Cycle

BOL; 0° Sun Angle

RESULTANT MATRIX OF	4	ITERATION FOR T									
1	-1.5791	2	5.5747	3	-77.7846	4	-74.3901	5	22.5840	6	77.5962
7	19.9324	8	18.5642	9	53.1812	10	-41.1778	11	-42.3417	12	-84.7361
13	-82.3216	14	-9.8491	15	-10.5469	16	-33.2177	17	-32.0975	18	-32.9247
19	-34.4895	20	-63.8492	21	-61.7283						

BOL; 30° Sun Angle

RESULTANT MATRIX OF	6	ITERATION FOR T									
1	6.6033	2	16.5742	3	-63.1981	4	-52.6764	5	31.8921	6	76.4236
7	29.3506	8	28.7222	9	58.5198	10	12.1350	11	11.3038	12	-22.6689
13	-21.8083	14	24.7463	15	24.2698	16	-0.7017	17	-0.1184	18	19.4534
19	18.3123	20	-9.9343	21	-8.6565						

BOL; 90° Sun Angle

RESULTANT MATRIX OF	7	ITERATION FOR T									
1	6.3201	2	6.4390	3	-52.4507	4	-43.3256	5	-12.1377	6	-24.8421
7	-7.0867	8	-12.4924	9	-13.6770	10	7.8747	11	6.3516	12	6.2871
13	9.0095	14	8.8147	15	-0.0649	16	0.4810	17	1.3586	18	10.8568
19	9.6091	20	13.1179	21	14.4282						

EOL; 0° Sun Angle

RESULTANT MATRIX OF	4	ITERATION FOR T									
1	2.0691	2	9.2715	3	-68.8762	4	-66.1214	5	26.1614	6	64.1541
7	23.5266	8	21.9203	9	55.3528	10	-38.5766	11	-36.6563	12	-79.3985
13	-77.1219	14	-4.7461	15	-5.4133	16	-29.5362	17	-28.4521	18	-27.1455
19	-28.6481	20	-59.4232	21	-57.3816						

EOL; 30° Sun Angle

RESULTANT MATRIX OF	6	ITERATION FOR T									
1	6.7078	2	17.8015	3	-61.4162	4	-50.5393	5	34.8388	6	81.5156
7	31.2834	8	30.7039	9	55.8652	10	17.5598	11	16.7598	12	-18.6444
13	-17.7029	14	29.8647	15	29.3977	16	3.0881	17	3.6680	18	36.9922
19	35.5073	20	1.9646	21	3.6572						

EOL; 90° Sun Angle

RESULTANT MATRIX OF	6	ITERATION FOR T									
1	6.4734	2	7.9011	3	-43.9252	4	-35.5923	5	-9.5015	6	-18.9585
7	-4.8171	8	-10.0466	9	-11.5916	10	18.3838	11	8.4688	12	16.8842
13	17.4592	14	4.9461	15	4.0518	16	9.1611	17	9.9744	18	21.9656
19	20.6567	20	34.1431	21	35.2568						

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 3.2.2-007-DN

Title

LAPI/Scan Platform Thermal Model Description and Performance

Written by: O. Liu	Date October 13, 1978
Approved by: C. Chhatpar	Date 16 OCT 78
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

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1. Summary

A 21-node thermal math model of Dynamics Explorer-B spacecraft LAPI (Low Altitude Plasma Instrument) and Scan Platform has been developed. The model has provided the temperature distribution in both cold case (90° sun angle) and hot case (30° sun angle) for various duty cycles. The model's geometry configuration, form factors, Radiation Couplings (RIJ's), view to space sink and orbit average external absorbed flux are generated by CDC TRASYS computer program. The steady state temperature distribution of two orbits are computed from RCA in-house TH014 steady-state thermal program. The nodal properties, conduction couplings (KIJ's) and power dissipations are supplied by GSFC. The spacecraft features simulated by this model are: magnetometer, LAPI stacks, scan platform, adapters, center column, driving motor housing , baseplate, and solar array.

The following data is contained in this report:

1. Plots and tables showing the nodal identification, properties and location.
2. Model's 3-dimension and orthographic view plots from TRASYS program.
3. Tables of absorbed nodal external flux.
4. Tables of data used in TH014.
5. Selected nodal temperature plots as function of instrument duty cycles.

2. Assumptions

1. The elliptical orbit has an apogee of 1200 km and a perigee of 275 km.
2. Heat is transferred by conduction and radiation.
3. Neglect the external flux incident through LAPI sensors slot openings.
4. Inside S/C is assumed as a sink of $25^{o}C$ and $0^{o}C$ for 30° sun angle and 90° sun angle respectively.
5. Magnetometer is in stowed position.
6. The scan platform (flower pot) has 75% see-through cutouts.
7. There is no wrap around the LAPI stacks.
8. Following design parameters are part of the model:
   a) Motor is hard-coupled to the diaphragm adapter.
   b) Diaphragm adapter is hard-coupled to the separation adapter.
   c) All internal surfaces of separation adapter, diaphragm adapter, scan platform are painted with Z306 chemglaze black.

3. Thermal Model and Performance

Two nodal identification systems are used for the model. One consists of 43 nodes for a geometry model, used in TRASYS program to generate view factors, RIJ and external fluxes; the other one is a 21 nodes thermal model used in THO14 program to predict the temperature performance. The nodes and sinks are shown in Table 1 through Table 3.

Table 4 to Table 7 are the data input for THO14 program to obtain the temperature distribution.

The nodal absorbed external flux of two orbits for 30^{0} and 90^{0} sun angles are listed in Table 8 and 9 respectively.

Due to the fact that view factors to the space of some external nodes are less than 1, the inaccuracy will occur when calculating the external abosrbed heat input. This has been compensated by adding the so called "S/C external nodal Absorbed Heat Input not accounted for with external sinks", as shown in Table 10, to the heat source data block in program THO14.

Table 11 lists the nodal heat input of various duty cycle for two different orbits.

The detail geometric configuration of the model are illustrated in Figure 1 through Figure 5.

The results of the analysis can be found in Table 12, Figure 6 and 7. The high voltage power supply and central electronic package will be operating at 39^{0}C in hot case (30^{0} sun angle and 100% duty cycle) and -9^{0}C in cold case (90^{0} sun angle and 0% duty cycle). The LAPI sensor stacks will be operating at 43^{0}C in hot case and -6^{0}C in cold case. The drive motor power dissipation of 6 watts is included in this analysis.

4. Discussion

Latest information from GSFC indicates that the most probable duty cycle of LAPI and scan platform will be 25% to 40%. The analysis has indicated that in this duty cycle, the HVPS (Node 17) and CEP (Node 18) will be operating at 31^{0}C in hot case and -1^{0}C in cold case. These are computer generated steady state temperature predictions which do not include uncertainty factor and thermal transients. The LAPI sensor stacks operational temperature, 38^{0}C in hot case, is considerably high. Therefore, a thermal shielding wrap around LAPI stack is recommended in order to reduce external flux impingement. Some fine-tuning of external properties may also be investigated, taking into account BOL vs EOL variation.

TABLE 1. NODAL IDENTIFICATION (for TH014)

TH14 Nodes	Description	Material	Corresponding TRASYS Nodes
1	Magnetometer		1-6
2	LAPI Stack #1	Mg Az 31 BH24	7
3	LAPI Stack #2	"	8
4	LAPI Stack #3	"	9
5	Magnetometer holding platform	"	10-11
6	Flower Pot Top Platform	"	16-17
7	Flower Pot Side	AL2024-T6	18-19
8	Adapter Top Spring Holder (Disc)	AL7075-773	34-35
9	Flower Pot bottom	AL2024-T6	20-21
10	Driving Motor Housing Adapter	AL6061-T6	22
11	Driving Motor Housing	"	23-25
12	Diaphragm adapter	MgAz31B	30-31
13	Driving motor housing bottom	A16061-T6	25
14	S/C Center Column	MgAz31BH24	36-37
15	Adapter (conical part)	A17075-773	38
16	Adapter (cylinder part)	"	32-33
17	High Voltage Power Supply	MgAz31B	45-49
18	Central Electronic Package	MgAz31B	51-55
19	Sun Shield (cylind	Stainless Steel	26
20	Solar Array	-	40-41
21	Inside S/C Environment	-	-

MODEL=SCALPI CONFIG=DFBLPI STEP=-1 ------DE-B LAPI & SCNPLTFM EXTERNAL FLUX, SUN ANG=30.--------
PROCESSING OPERATIONS DATA

NODE	BCS	AREA	ALPH	EMISS	SURF. TYPE	ACTIVE	--------COMMENTS----------	THRM NODE	SINK #
1	MGNTME	.183333	.380	.640	RECTANGLE	TOP	MAGNETOMETER		
2	MGNTME	.8333336E-01	.380	.640	RECTANGLE	TOP	MAGNETOMETER		
3	MGNTME	.137500	.380	.640	RECTANGLE	TOP	MAGNETOMETER	1	1
4	MGNTME	.8333336E-01	.380	.640	RECTANGLE	TOP	MAGNETOMETER		
5	MGNTME	.137500	.380	.640	RECTANGLE	TOP	MAGNETOMETER		
6	MGNTME	.183333	.380	.640	RECTANGLE	TOP	MAGNETOMETER		
7	LAPIOB	.763582	.600	.860	CYLINDER	OUTSID	LAPI NO.1 STACK	2	2
8	LAPIOB	.763582	.600	.860	CYLINDER	OUTSID	LAPI NO.2 STACK	3	3
9	LAPIOB	.763582	.600	.860	CYLINDER	OUTSID	LAPI NO3.STACK	4	4
10	LAPIOB	1.19174	.380	.640	DISC	BOTTOM	MGNTMETER HOLDER	5	5
11	LAPIOB	1.19174	.380	.640	DISC	TOP	MGNTMETER HOLDER		
16	SKNPLF	1.19574	.260	.860	DISC	BOTTOM	TOP OF SCAN PLATFORM	6	6
17	SKNPLF	1.19674	.260	.860	DISC	TOP	TOP OF SCAN PLATFORM		
18	SKNPLF	2.71508	1.000	.860	CYLINDER	INSIDE	SCAN PLATFORM HOUSING	7	
19	SKNPLF	2.71508	1.000	.860	CYLINDER	OUTSID	SCAN PLATFORM HOUSING		
20	SKNPLF	.935407	.260	.860	DISC	BOTTOM	BOTTOM OF SCAN PLATFORM	9	
21	SKNPLF	.935407	.260	.860	DISC	TOP	BOTTOM OF SCAN PLATFORM		
22	SKNPLF	.7867332E-01	1.000	.860	CYLINDER	OUTSID	CONNECTOR OF PLTFORM HUSNG &	10	
23	SKNPLF	.1022665	1.000	.860	DISC	TOP	DRVNG UNIT TOP	11	
24	SKNPLF	.993330	1.000	.860	CYLINDER	OUTSID	DRVNG UNIT		
25	SKNPLF	.125004	1.000	.860	DISC	BOTTOM	BOTTOM OF DRVNG UNIT	13	
26	SKNPLF	.870311	1.000	.860	CYLINDER	OUTSID	SUN-SHIELD FOR SCANPLTFM	19	9
30	SEPADP	.699895	1.000	.860	DISC	BOTTOM	DRVNG UNIT SUPPORTOR	12	
31	SEPADP	.699895	1.000	.860	DISC	TOP	DRVNG UNIT SUPPORTOR		
32	SEPADP	.763582	1.000	.860	CYLINDER	INSIDE	SCAN PLATFORM HOLDER	16	8
33	SEPADP	.763582	.200	.860	CYLINDER	OUTSID	SCAN PLATFORM HOLDER		
34	SEPADP	.616638	.200	.860	DISC	BOTTOM	SEPERATOR TOP	8	7
35	SEPADP	.616638	.200	.860	DISC	TOP	SEPERATOR TOP		
36	SEPADP	5.49779	1.000	.860	CYLINDER	INSIDE	CENTER COLUMN	14	
37	SEPADP	.795138	1.000	.860	DISC	TOP	CENTER COLUMN		
38	SEPADP	3.28556	1.000	.860	CONE	INSIDE	CONICAL ADPTR	15	
40	SOLARY	12.8517	.750	.810	DISC	TOP	TOP SOLAR ARRAY	20	NC
41	SOLARY	50.6582	.750	.810	CYLINDER	OUTSID	SIDE ARRAY		
45	ELCTBX	.303496	1.000	.860	RECTANGLE	TOP	HIGH VOLTAGE ELECTRONICS		
46	ELCTBX	.227665	1.000	.860	RECTANGLE	TOP	HIGH VOLTAGE ELECTRONICS		
47	ELCTBX	.364824	1.000	.860	RECTANGLE	TOP	HIGH VOLTAGE ELECTRONICS	17	
48	ELCTBX	.227665	1.000	.860	RECTANGLE	TOP	HIGH VOLTAGE ELECTRONICS		
49	ELCTBX	.364824	1.000	.860	RECTANGLE	TOP	HIGH VOLTAGE ELECTRONICS		
51	ELCTBX	.199999	1.000	.860	RECTANGLE	TOP	LOW VOLTAGE ELECTRONICS		
52	ELCTBX	.284333	1.000	.860	RECTANGLE	TOP	LOW VOLTAGE ELECTRONICS		
53	ELCTBX	.364583	1.000	.860	RECTANGLE	TOP	LOW VOLTAGE ELECTRONICS	18	
54	ELCTBX	.276323	1.000	.860	RECTANGLE	TOP	LOW VOLTAGE ELECTRONICS		
55	ELCTBX	.364583	1.000	.860	RECTANGLE	TOP	LOW VOLTAGE ELECTRONICS		

ADJUSTING FIELD LENGTH TO 151100 FOR THE FF SEGMENT

Table 2. Geometric Thermal Model Nodal Identification

Table 3. Sink Identification

Sink #	Description
1	Magnetometer
2	LAPI Stack #1
3	LAPI Stack #2
4	LAPI Stack #3
5	Magnetometer holding platform
6	Flower Pot Top Platform
7	Adapter top sping holder
8	Adapter (cylinder part)
9	Sun shield
10	Solar Array
11	Inside S/C environment

Table 4. Orbit Average External Sink Value I_S (watts/in^2)

Sink #	Apogee = 1200 Km Perigee = 275 Km	
	Sun Angle	
	30^0	90^0
1	.268	.122
2	.125	.142
3	.092	.147
4	.122	.142
5	.448	.207
6	.077	.017
7	.154	.043
8	.085	.062
9	.071	.063
10	.738	.066
11	.0	.0

Table 5. Internal Radiation Couplings (in^2)

INPUT MATRIX VALUES FOR KIJ											
1	5	8.405 [illegible]0	1	[illegible]	3.[illegible]7[illegible]0	1	[illegible]	[illegible]	1	22	2.251000
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	9	0.[illegible]	2	1[illegible]	0.[illegible]	[illegible]	13	0.[illegible]	2	23	14.[illegible]0000
3	4	6.235[illegible]0	3	5	[illegible].36[illegible]0	3	6	9.[illegible]500[illegible]	[illegible]	8	0.729000
[illegible]	1[illegible]	[illegible]	[illegible]	13	0.[illegible]1[illegible]	[illegible]	20	1[illegible]	[illegible]	5	[illegible]
4	6	9.[illegible]14[illegible]0	4	[illegible]	0.[illegible]5200[illegible]	4	15	0.[illegible]9460[illegible]	4	1[illegible]	0.029000
[illegible]	25	15.[illegible]	[illegible]	[illegible]	0.[illegible]1[illegible]0	5	8	[illegible].[illegible]17[illegible]0	5	16	0.053000
[illegible]	14	[illegible].[illegible]18[illegible]	[illegible]	[illegible]	16.[illegible]1[illegible]63	[illegible]	[illegible]	22.[illegible]7[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	9	5.[illegible]7[illegible]	[illegible]	17	15.[illegible]46[illegible]0	6	1[illegible]	11.[illegible]22[illegible]	[illegible]	2[illegible]	[illegible]
7	8	15.17[illegible]0	7	[illegible]	61.[illegible]2[illegible]31	7	1[illegible]	[illegible].[illegible]94[illegible]	7	11	1.170000
7	12	2.31[illegible]	7	14	[illegible].[illegible]9[illegible]	7	15	[illegible].[illegible]3[illegible]	7	16	[illegible]
7	17	24.1[illegible]	7	1[illegible]	1[illegible].[illegible]999	8	9	[illegible].[illegible]43[illegible]	[illegible]	11	[illegible]
[illegible]	12	[illegible].[illegible]7[illegible]	[illegible]	[illegible]	[illegible].3[illegible].[illegible]7[illegible]	[illegible]	1[illegible]	2[illegible].[illegible]3[illegible]	[illegible]	1[illegible]	[illegible]
[illegible]	21	[illegible].[illegible]	[illegible]	1[illegible]	2.[illegible].[illegible]000	[illegible]	11	16.[illegible]3[illegible]	[illegible]	12	[illegible]
[illegible]	14	[illegible].[illegible]97[illegible]	[illegible]	1[illegible]	[illegible].[illegible]45[illegible]56	[illegible]	1[illegible]	[illegible].[illegible]2[illegible]	[illegible]	17	2[illegible].[illegible]7081
[illegible]	18	2[illegible].17[illegible]3	1[illegible]	11	1.[illegible]0[illegible]	1[illegible]	12	[illegible].[illegible]145[illegible]	1[illegible]	15	1.233000
11	11	[illegible].[illegible]97[illegible]	11	12	2[illegible].[illegible]5[illegible]	11	13	[illegible].[illegible]1[illegible]	11	14	[illegible]
11	15	15.13[illegible]5	11	1[illegible]	[illegible].[illegible]7[illegible]	12	12	[illegible].[illegible]2[illegible]	12	13	[illegible]
12	14	1.[illegible]3[illegible]	12	15	[illegible].[illegible]93	12	16	[illegible].[illegible]157[illegible]	13	14	14.[illegible]3000
[illegible]	19	91.[illegible]3[illegible]	[illegible]	[illegible]	1.[illegible]3[illegible]	[illegible]	[illegible]	[illegible].[illegible]27[illegible]	[illegible]	[illegible]	[illegible]
15	15	13.1[illegible]	[illegible]	17	72.[illegible]4[illegible]	15	1[illegible]	[illegible].[illegible]2[illegible]	15	21	3[illegible].[illegible]45547
[illegible]	14	[illegible].2[illegible]	1[illegible]	[illegible]	21.[illegible]4[illegible]	17	1[illegible]	[illegible].[illegible]19[illegible]	19	20	7.013000

Table 6. Conductive Couplings (watts/^0C)

INPUT MATRIX VALUES FOR KIJ											
1	5	[illegible].[illegible]9	[illegible]	[illegible]	0.[illegible]70000	2	6	0.[illegible]78[illegible]	3	5	0.270000
3	5	[illegible].[illegible]	[illegible]	[illegible]	0.[illegible]78[illegible]	[illegible]	[illegible]	0.[illegible]78[illegible]	[illegible]	[illegible]	[illegible]
5	1[illegible]	[illegible].[illegible]8[illegible]	[illegible]	12	1.141000	6	12	[illegible].[illegible]1[illegible]	7	9	0.244000
9	11	3.[illegible]7[illegible]	11	11	[illegible].[illegible]7[illegible]	11	12	1.[illegible]23[illegible]	11	13	0.157000
[illegible]	14	1.[illegible]	[illegible]	[illegible]	1.[illegible]1[illegible]	[illegible]	[illegible]	1.[illegible]3[illegible]	[illegible]	[illegible]	[illegible]

Table 7 - External Radiation Couplings (in^2)

INPUT MATRIX VALUES FOR KIJ											
1	1	1[illegible].[illegible]93 .5	2	2	46.[illegible]24[illegible]4	3	3	47.[illegible]7[illegible]5	4	4	54.[illegible]42[illegible]1
[illegible]	5	[illegible].21[illegible]7	[illegible]	[illegible]	53.[illegible]53[illegible]	[illegible]	7	[illegible].[illegible]2[illegible]	1[illegible]	[illegible]	[illegible]
1[illegible]	9	34.[illegible]3[illegible]	[illegible]	1[illegible]	1[illegible].[illegible]	21	11	[illegible].[illegible]0			

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Table 8. S/C External Nodal Absorbed Heat Input Not Accounted for with External Sinks (Watts)

Node #	Apogee = 1200 Km Perigee = 275 Km	
	Sun Angle	
	30°	90°
1	0	.0
2	6.014	6.599
3	4.33	6.78
4	4.83	5.401
5	9.769	1.476
6	2.16	.626
7	0	0
8	1.97	0.553
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	2.19	1.601
17	0	0
18	0	0
19	1.43	1.243
20	0	0
21	0	0

Table 9. Nodal Absorbed External Heat Flux - Sun Angle = 30°

DATE 10/06/78 TIME 09.34.39 THERMAL RADIATION ANALYSIS SYSTEM (TRASYS) CDC6[illegible]/SCOPE 3.4 PAGE 68

MODEL=SCALPI CONFIG=DEGLPI ST-P=1[illegible] ------DE-B LAPI & SCALPTEM EXTERNAL FLUX, SUN ANG=30.--------
ABSORBED Q OUTPUT COMPUTATION LINK.

AVERAGE ORBITAL HEATING FLUX AND AREA CARDS PUNCHED

VALUE, ARE FLUX = INPUT (UNITS) * EXPF WHERE EXPF = .10130E+01
VALUE, ARE AREA = INPUT (UNITS) * AMPF WHERE AMPF = .10000E+01

0	1=	.1531.67[illegible]	.18[illegible]E+01	1.0000	$
0	2=	.427[illegible]	.43[illegible]E-01	1.0000	$
0	3=	.7[illegible]	.13[illegible]E+01	1.0000	$
0	4=	.[illegible]	.43[illegible]E-01	1.0000	$
0	5=	.5[illegible]	.13[illegible]E+01	1.0000	$
0	6=	.1[illegible]	.18[illegible]E+00	1.0000	$
0	7=	.[illegible]	.76[illegible]E+00	1.0000	$
0	8=	.[illegible]	.76[illegible]E+01	1.0000	$
0	9=	.[illegible]	.76[illegible]E+01	1.0000	$
0	10=	.[illegible]	.73[illegible]E+00	1.0000	$
0	11=	.12[illegible]	.36[illegible]E+01	1.0000	$
0	12=	0.	.64[illegible]E+01	1.0000	$
0	13=	.[illegible]	.73[illegible]E+00	1.0000	$
0	14=	0.	.27[illegible]E+01	1.0000	$
0	15=	0.	.27[illegible]E+01	1.0000	$
0	16=	0.	.89[illegible]E+01	1.0000	$
0	17=	0.	.93[illegible]E+01	1.0000	$
0	18=	0.	.56[illegible]E-01	1.0000	$
0	19=	0.	.65[illegible]E-01	1.0000	$
0	20=	0.	.20[illegible]E+01	1.0000	$
0	21=	0.	.12[illegible]E+01	1.0000	$
0	22=	.28[illegible]E+02	.87[illegible]E+00	1.0000	$
0	23=	0.	.59[illegible]E+01	1.0000	$
0	24=	0.	.59[illegible]E+01	1.0000	$
0	25=	.35[illegible]E+02	.76[illegible]E+00	1.0000	$
0	26=	0.	.41[illegible]E+01	1.0000	$
0	27=	.[illegible]	.16[illegible]E+01	1.0000	$
0	28=	0.	.34977[illegible]E+01	1.0000	$
0	29=	0.	.78539[illegible]E+00	1.0000	$
0	30=	0.	.32[illegible]E+01	1.0000	$
0	40=	.2934[illegible]E+02	.12[illegible]E+02	1.0000	$
0	41=	.[illegible]	.50[illegible]E+02	1.0000	$
0	45=	0.	.30[illegible]E+01	1.0000	$
0	46=	0.	.22[illegible]E+00	1.0000	$
0	47=	0.	.36[illegible]E+01	1.0000	$
0	48=	0.	.22[illegible]E+00	1.0000	$
0	49=	0.	.36[illegible]E+01	1.0000	$
0	51=	0.	.19444444E+00	1.0000	$
0	52=	0.	.28[illegible]E+00	1.0000	$
0	53=	0.	.36[illegible]E+01	1.0000	$
0	54=	0.	.20[illegible]E+00	1.0000	$
0	55=	0.	.36[illegible]E+01	1.0000	$

TOTAL TIME TO COMPUTE ABSORBED Q OUT .29

ADJUSTING FIELD LENGTH TO 035200 FOR THE OD SEGMENT

3.2.2-007-0N
Page 10.

Table 10. Nodal Absorbed External Heat Flux, - Sun Angle = 90°

MODEL=SCALPI CONFIG=DEALPI STEP=1 ...
ABSORBED ... OUTPUT COMPUTATION LINK.

-------DEFAULT $ SCNPLTEM EXTERNAL FLUX, SUN ANG=90.--------

AVERAGE ORBITAL HEATING FLUX AND AREA CARDS PUNCHED

VALUES ARE FLUX = INPUT (UNITS) * FMPF WHERE FMPF = .10000E+01
VALUES ARE AREA = INPUT (UNITS) * AMPF WHERE AMPF = .10000E+01

2	1=	.1[illegible]	.1[illegible]	$
2	2=	.4[illegible]	.8333333[illegible]	$
2	3=	.4[illegible]	.1[illegible]	$
2	4=	.5[illegible]	.[illegible]	$
2	5=	.473[illegible]	.1375000[illegible]	$
2	6=	.[illegible]	.1[illegible]	$
2	7=	.[illegible]	.[illegible]	$
2	8=	.[illegible]	.[illegible]	$
2	9=	.[illegible]	.[illegible]	$
2	10=	.[illegible]	.[illegible]	$
2	11=	.[illegible]	.[illegible]	$
2	12=	0.	.[illegible]	$
2	13=	.[illegible]	.[illegible]	$
2	14=	0.	.[illegible]	$
2	15=	0.	.[illegible]	$
2	16=	0.	.[illegible]	$
2	17=	0.	.[illegible]	$
2	18=	0.	.[illegible]	$
2	19=	0.	.[illegible]	$
2	20=	0.	.[illegible]	$
2	21=	0.	.[illegible]	$
2	22=	0.	.[illegible]	$
2	23=	0.	.[illegible]	$
2	24=	0.	.[illegible]	$
2	25=	0.	.[illegible]	$
2	26=	.[illegible]	.[illegible]	$
2	27=	0.	.[illegible]	$
2	28=	0.	.[illegible]	$
2	29=	0.	.[illegible]	$
2	30=	.[illegible]	.[illegible]	$
2	31=	.[illegible]	.[illegible]	$
2	32=	0.	.[illegible]	$
2	33=	.26331[illegible]	.[illegible]	$
2	34=	0.	.[illegible]	$
2	35=	.[illegible]	.[illegible]	$
2	36=	0.	.[illegible]	$
2	37=	0.	.[illegible]	$
2	38=	0.	.[illegible]	$
2	40=	.[illegible]	.[illegible]	$
2	41=	.[illegible]	.[illegible]	$
2	45=	0.	.[illegible]	$
2	46=	0.	.2278649[illegible]	$
2	47=	0.	.3648923[illegible]	$
2	48=	0.	.[illegible]	$
2	49=	0.	.3648923[illegible]	$
2	51=	0.	.1944444[illegible]	$
2	52=	0.	.[illegible]	$
2	53=	0.	.[illegible]	$
2	54=	0.	.[illegible]	$
2	55=	0.	.[illegible]	$

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TOTAL TIME TO COMPUTE ABSORBED ... OUT .28

ADJUSTING FIELD LENGTH TO 03630) FOR THE DD SEGMENT

Table 11-1 - Nodal Internal Power Dissipation

Node #	Description	Power Dissipation (watts)
1	Magnetometer	.1
2-3-4	LAPI Sensor	6.3
11,13	Driving Motor	6.0
17	High Voltage Power Supply	4.2
18	Central Electronics Package	7.3

Table 11-2 LAPI/Scan Platform Total Nodal Power Distribution

Node #	External flux power not accounted Sun Angle		Instrument Duty Cycle				Q Total							
							30^0 Sun Angle				90^0 Sun Angle			
	30^0	90^0	100%	50%	25%	0%	100%	50%	25%	0%	100%	50%	25%	0%
1	0	0	.1	.05	.025	0	.1	.05	.025	0	.1	.05	.025	0
2	6.014	6.699	2.1	1.05	0.525	0	8.114	7.064	6.539	6.014	8.799	7.749	7.224	6.699
3	4.33	6.78	2.1	1.05	0.525	0	6.43	5.38	4.855	4.33	8.88	7.83	7.305	6.78
4	4.83	5.401	2.1	1.05	0.525	0	6.93	6.88	5.355	4.83	7.501	6.451	5.926	5.401
5	9.769	1.476	0	0	0	0	9.769	9.769	9.769	9.769	1.476	1.476	1.476	1.476
6	2.16	.626	0	0	0	0	2.16	2.16	2.16	2.16	.626	.626	.626	.626
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1.97	.553	0	0	0	0	1.97	1.97	1.97	1.97	.553	.553	.553	.553
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0				0				0				0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	1.	0.5	.25	0	1.0	.5	.25	0	1.	.5	.25	0
14	0	0	5.	2.5	1.25	0	5.0	2.5	1.25	0	5.	2.5	1.25	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	2.19	1.601	0	0	0	0	2.19	2.19	2.19	2.19	1.601	1.601	1.601	1.601
17	0	0	4.2	2.1	1.05	0	4.2	2.1	1.05	0	4.2	2.1	1.05	0
18	0	0	7.3	3.65	1.82	0	7.3	3.65	1.875	0	7.3	3.65	1.825	0
19	1.43	1.243	0	0	0	0	1.43	1.43	1.43	1.43	1.243	1.243	1.243	1.243
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0

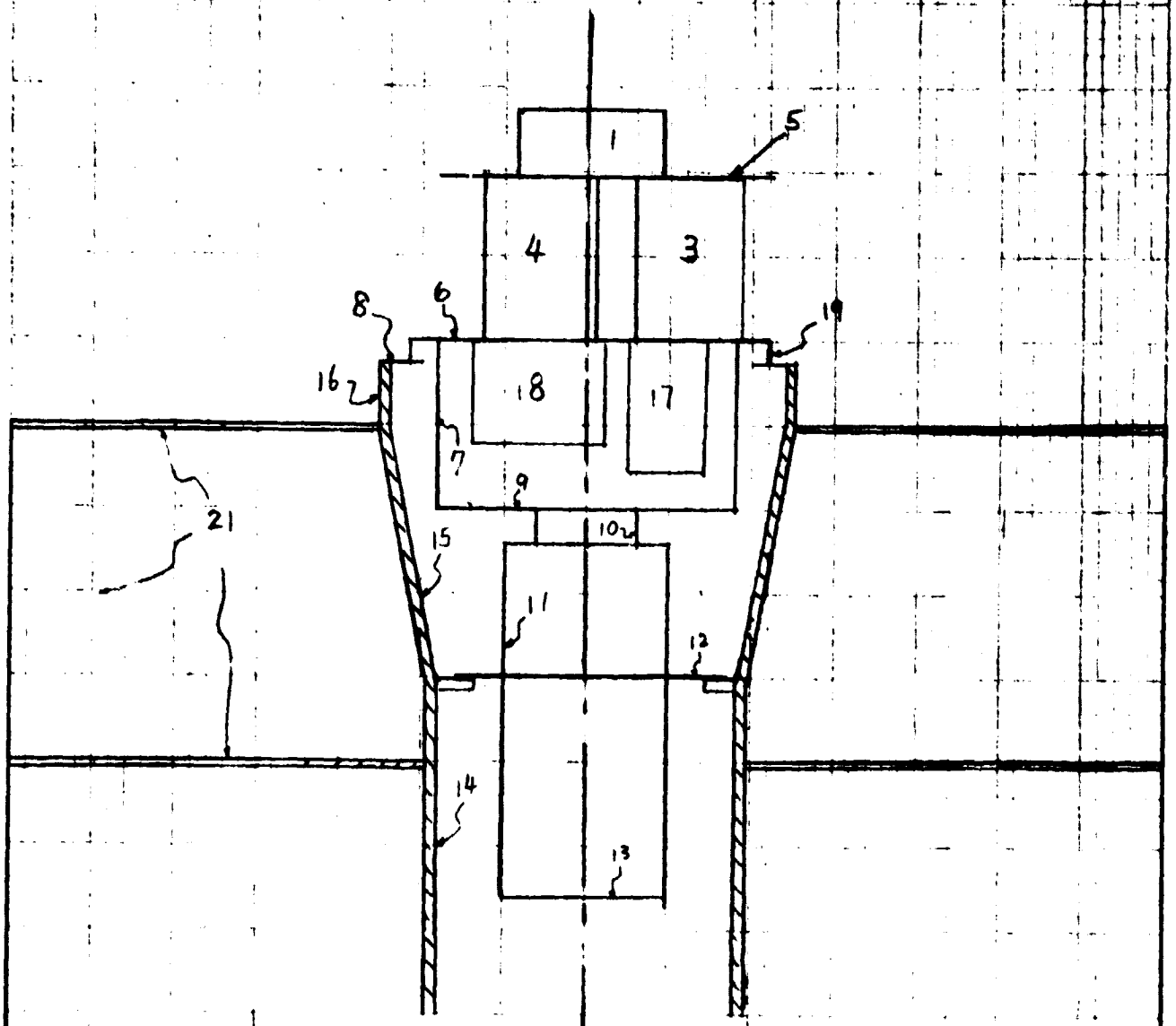
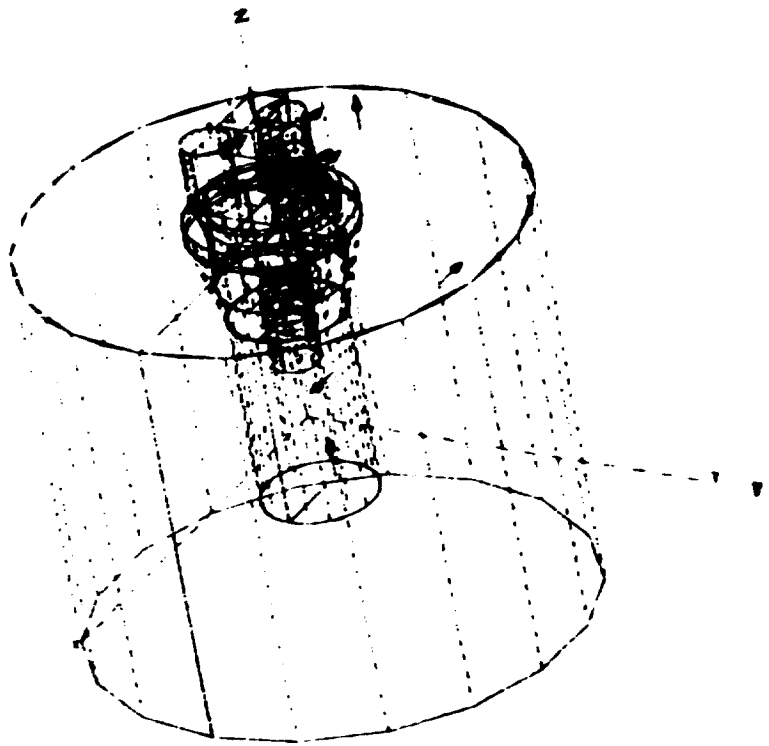


Figure 1. LAPI/Scan Platform Schematic and Nodal Identification

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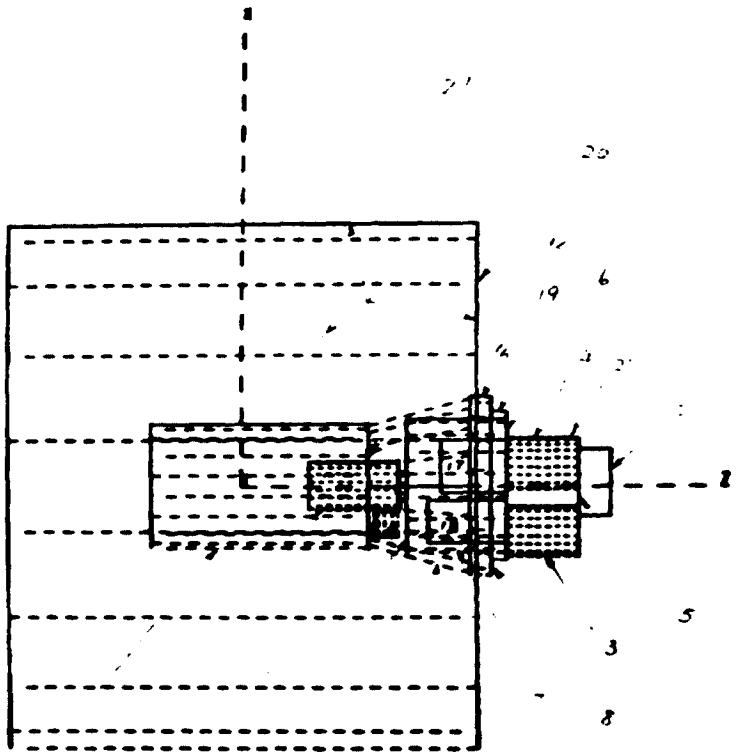
DE-B LAPI AND SCAN PLATFORM THERMAL ANALYSIS



VIEW = 3-0
SCALE = 0.650
VIEW NUMBER = 1

Figure 2.

DE-B LAPI AND SCAN PLATFORM THERMAL ANALYSIS



VIEW = Y-AXIS
SCALE = .0850
VIEW NUMBER = 1

Figure 3.

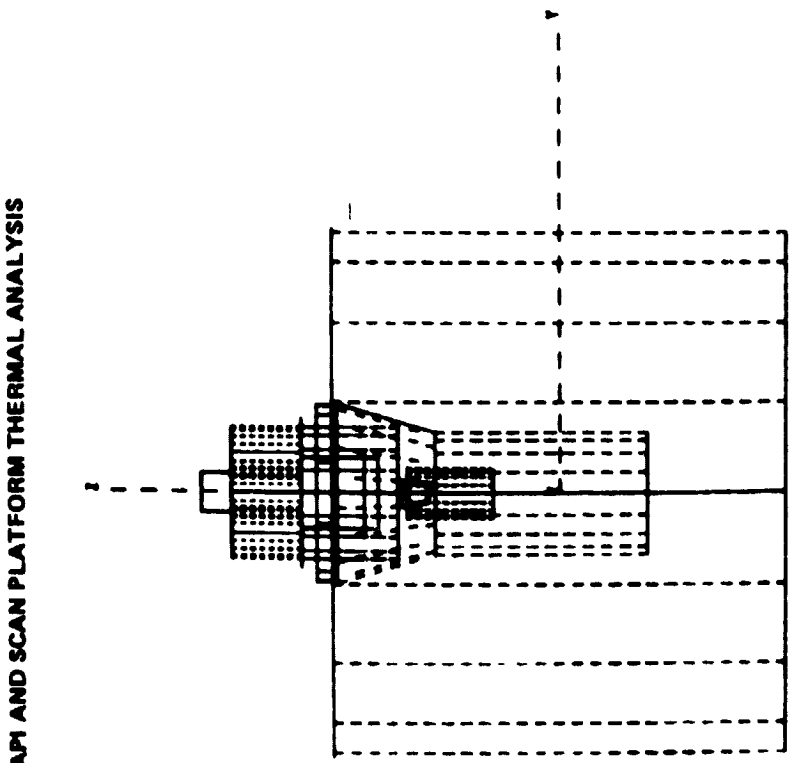

DE-8 LAPI AND SCAN PLATFORM THERMAL ANALYSIS
VIEW = X-AXIS
SCALE = .0050
VIEW NUMBER = 1

Figure 4.

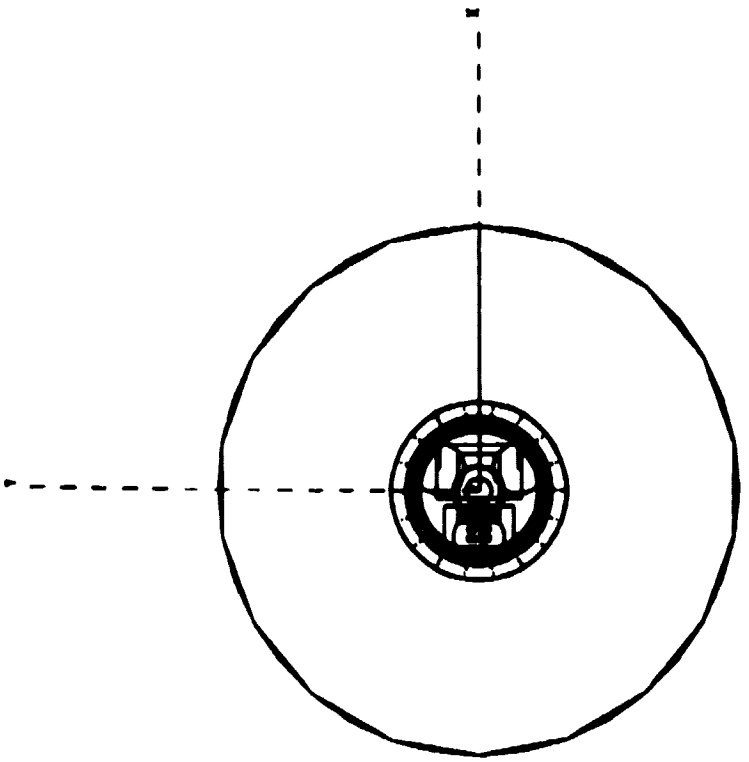

DE-8 LAPI AND SCAN PLATFORM THERMAL ANALYSIS
VIEW = Z-AXIS
SCALE = .0650
VIEW NUMBER = 1

Figure 5.

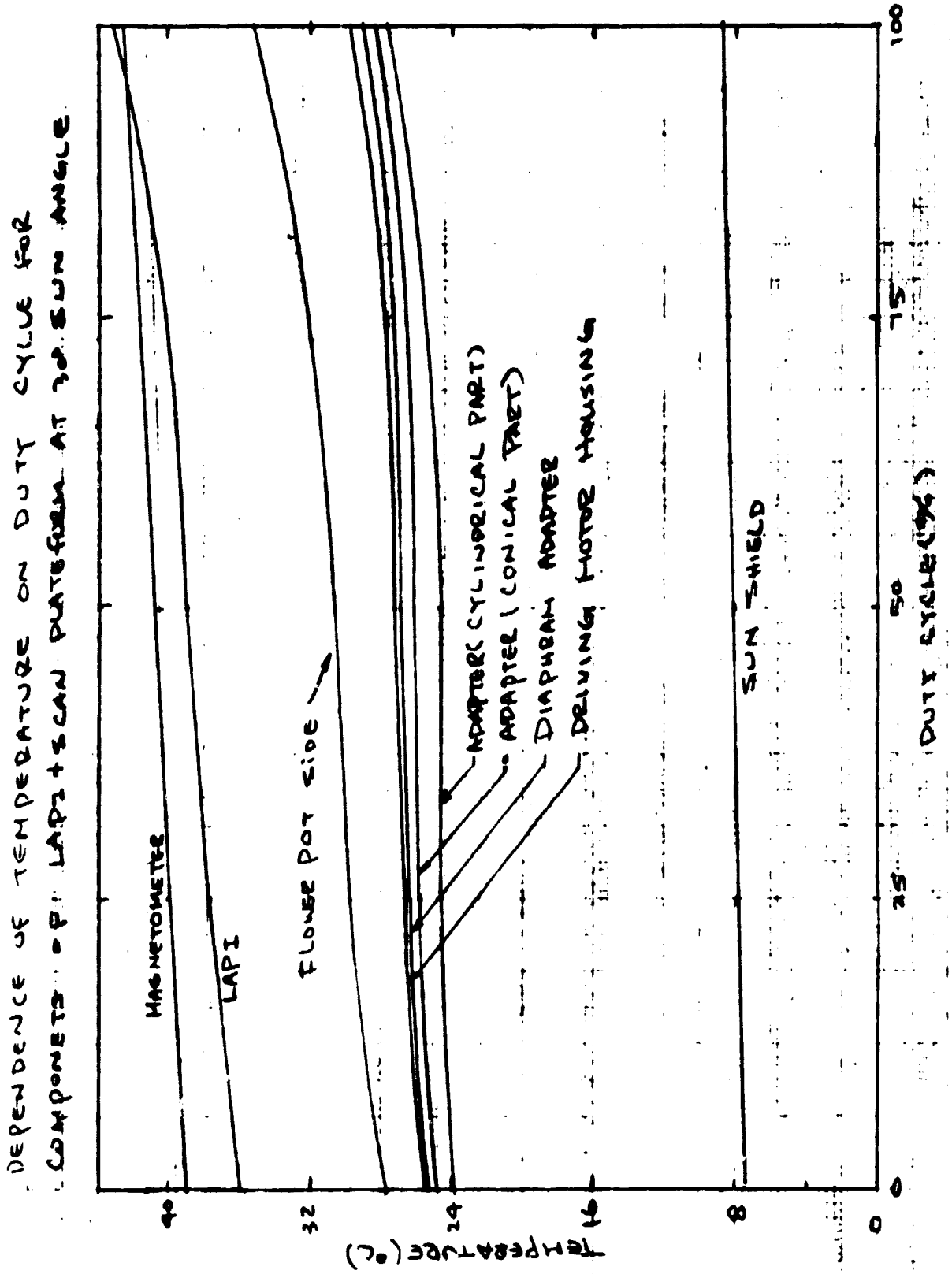


Figure 6:

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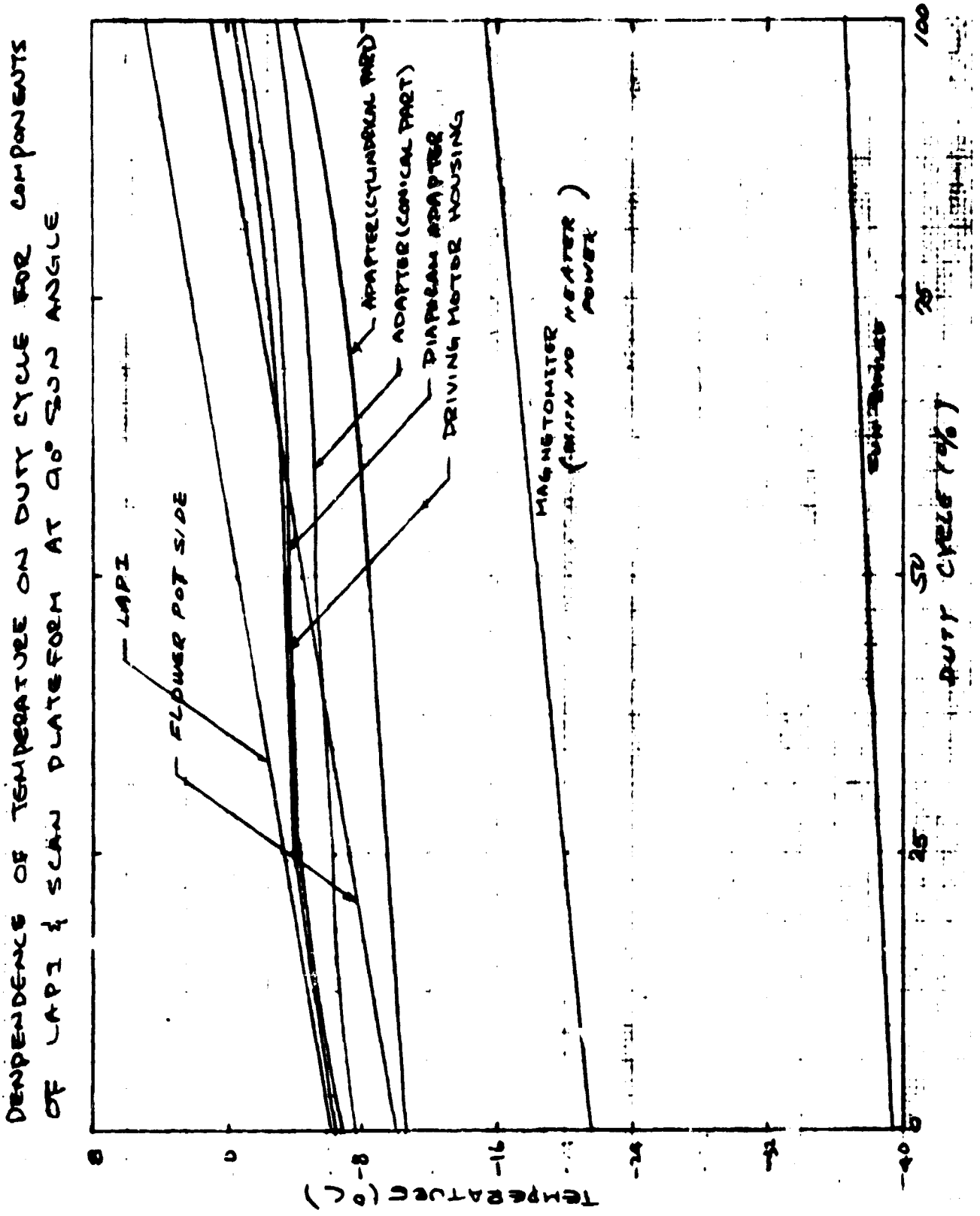


Figure 7.

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RESULTANT MATRIX OF 4 ITERATION FOR T — SUN ANG = 30°

1	[illegible]	2	44.7719	3	42.4524	4	41.9451	5	56.6657	6	37.3931
7	35.1995	8	10.0682	9	33.5073	10	31.5513	11	29.7036	12	29.1186
13	34.0442	14	28.9661	15	28.3372	16	27.2317	17	38.3132	18	39.9709
19	6.8447	20	100.6453	21	25.0657						

RESULTANT MATRIX OF 4 ITERATION FOR T — SUN ANG = 30°, DUTY CYC = 50%

1	40.5461	2	40.7146	3	38.1531	4	37.7632	5	55.6533	6	32.3926
7	30.5263	8	12.3207	9	29.3135	10	28.2671	11	27.2671	12	26.8643
13	29.5654	14	27.3215	15	26.1533	16	24.5693	17	30.5703	18	33.2227
19	7.9978	20	100.5293	21	25.0330						

RESULTANT MATRIX OF 4 ITERATION FOR T — SUN ANG = 30°, DUTY CYC = 25%

1	39.3579	2	39.4741	3	36.9055	4	36.5364	5	54.7871	6	31.2666
7	25.9741	8	12.1006	9	28.5144	10	27.5683	11	26.5452	12	26.3636
13	27.7554	14	26.7156	15	25.6843	16	24.7263	17	30.4269	18	31.2581
19	7.2370	20	100.3022	21	25.0255						

RESULTANT MATRIX OF 4 ITERATION FOR T — SUN ANG = 30°, DUTY CYC = 0%

1	39.0950	2	37.5330	3	34.5543	4	34.6177	5	53.4297	6	29.7955
7	27.7217	8	11.4265	9	26.7720	10	26.1669	11	35.4951	12	35.4377
13	25.6167	14	25.7460	15	24.7776	16	23.8413	17	27.6421	18	28.2156
19	7.4851	20	100.4534	21	25.0051						

RESULTANT MATRIX OF 4 ITERATION FOR T — SUN ANG = 90°, DUTY CYC = 100%

1	-1.7457	2	5.2134	3	5.4211	4	3.8613	5	2.9419	6	1.8905
7	0.6623	8	-31.5786	9	0.7391	10	0.0538	11	-0.4580	12	-8.8870
13	4.7185	14	3.6821	15	-2.9346	16	-6.1611	17	5.2612	18	6.1345
19	-36.5635	20	-46.4705	21	-0.0132						

RESULTANT MATRIX OF 4 ITERATION FOR T — SUN ANG = 90°, DUTY CYC = 50%

1	-16.4853	2	-9.3296	3	-0.0170	4	-1.5896	5	-1.4309	6	-3.8833
7	-9.4593	8	-35.7450	9	-3.8675	10	-3.5656	11	-3.0391	12	-3.1985
13	-6.1532	14	-1.1428	15	-5.2559	16	-8.3586	17	-1.8838	18	-1.5955
19	-39.0817	20	-61.3905	21	-0.0498						

RESULTANT MATRIX OF 4 ITERATION FOR T — SUN ANG = 90°, DUTY CYC = 25%

1	[illegible]	2	-3.1531	3	-2.6245	4	-4.3701	5	[illegible]	6	-6.4011
7	-7.4186	8	-38.4341	9	-6.2461	10	-5.3279	11	-4.3626	12	-4.3667
13	-2.6333	14	-2.5501	15	-6.4128	16	-9.4849	17	-5.5742	18	-5.5464
19	-38.4867	20	-61.6676	21	-0.0728						

RESULTANT MATRIX OF 4 ITERATION FOR T — SUN ANG = 90°, DUTY CYC = 0%

1	-21.7203	2	-6.1911	3	-6.7749	4	-7.2944	5	-6.0735	6	-16.3852
7	-18.0301	8	-39.3873	9	-8.7068	10	-7.2151	11	-5.4784	12	-5.5118
13	-5.1911	14	-2.3851	15	-7.5942	16	-10.6365	17	-9.4441	18	-9.7332
19	-39.4065	20	-61.9108	21	-0.0925						

Table 12. Temperature Distribution of all Cases

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DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 3.2.2-008-DN

Title

DE-A ATC THERMAL DESIGN AND PERFORMANCE

Written by: C. Chhatpar	Date Oct. 13, 1978
Approved by: W. V. Fuldner	Date Oct. 13, 1978
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

Letter	Description	Date	Author

Standard Distribution:
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1. SUMMARY

Because of sun impingement on all sides of the DE-A spacecraft, the hot end solar array causes high temperature problems for the louver actuator design. The bimetallic actuator needs to be cooled to reasonably low temperature levels so that a louver passive set point can be selected which results in acceptable normal louver operation. This note presents a design configuration that incorporates an insulating structural block between the bimetallic housing and the end solar array substrate. Additionally, there is a cold patch concentric with and larger than the housing diameter to locally cool the structural block. Both design changes help achieve acceptable temperature ranges for the bimetallic spring and the housing.

Only the hot end problem is analyzed here. It is assumed that the cold end (normal louver operation) design is substantially the same as for the Atmosphere Explorer louver design.

2. DESIGN REQUIREMENTS

The active-thermal-control hardware required for the DE-A spacecraft includes louvers on both ends of the spacecraft. The louvers (either end) are used in their normal mode (i.e., like DE-B) when they are not sun-illuminated. Since DE-A will not perform a 180-degree rotation when the sun crosses the orbit plane, the sun will be incident on each side of the spacecraft at some point in the mission. Figure 1 shows the louver configuration when sun-illuminated. The ATC portion of the end solar array will achieve an average temperature of 80°C when normally illuminated with the louvers closed. The primary design concern is one of effective isolation and cooling of the bimetal housing when its side of the spacecraft is illuminated. One design approach is to cover a portion (preferably a diameter concentric with larger than the housing) of the hat with a low α/ε surface that will reduce the maximum temperature of the hat section immediately adjacent to the bimetal housing, resulting in a more desirable operating environment. This technique also relies on a relatively low conduction from the solar-cell-covered portion of the ATC part of the end solar array to the low α/ε covered portion via locally reduced skin thickness or low thermal-conductivity materials as shown in Figure 2.

The end solar array achieves a maximum temperature of 80°C for +18° sun angle. This is the assumed design case for which the bimetal coil will be designed. The sunlit louvers will be commanded close by disabling the ATCE bimetallic heater. This puts the ATC under the passive operation whereby the passive set point (the temperature where bimetallic heater starts to open, without being supplied external heater power, by being radiatively coupled to the hot end array) of the bimetallic heater should be higher than the actual temperature achieved.

3. DESIGN CONFIGURATION

The louver actuator housing design shown in Figure 2 is the same as that of AE spacecraft, except for the following additions:

a) There is a bimetal-housing-support block of low-conductivity material. This structural block provides isolation of the bimetal housing from the hot end array substrate. Two different materials are investigated to carry out the parametric study to evaluate the effect of conductivity on the bimetallic coil temperature.

b) There is a cold patch concentric with and larger than the actuator housing diameter. This patch 10 mil Al/Teflon, bonded on space facing side of the structural block, will provide a local cooling effect of the structural block, thereby assisting the block to isolate the actuator housing from the substrate.

The dynamic loads and stress analysis of this configuration will have to show that addition of this structural block can be accomplished by the two selected or other available materials. Any design change dictated by the stress analysis can be incorporated without altering the major thermal assumptions. Table 1 shows the mechanical and thermal properties of the two selected materials.

TABLE 1. CANDIDATE STRUCTURAL BLOCK MATERIAL PROPERTIES

Material	Thermal Conductivity watts/in/°C	Tensile Ult. Strength (psi)
Polycarbofil G50/40	.00136	23,000
G11	.0074	40,000

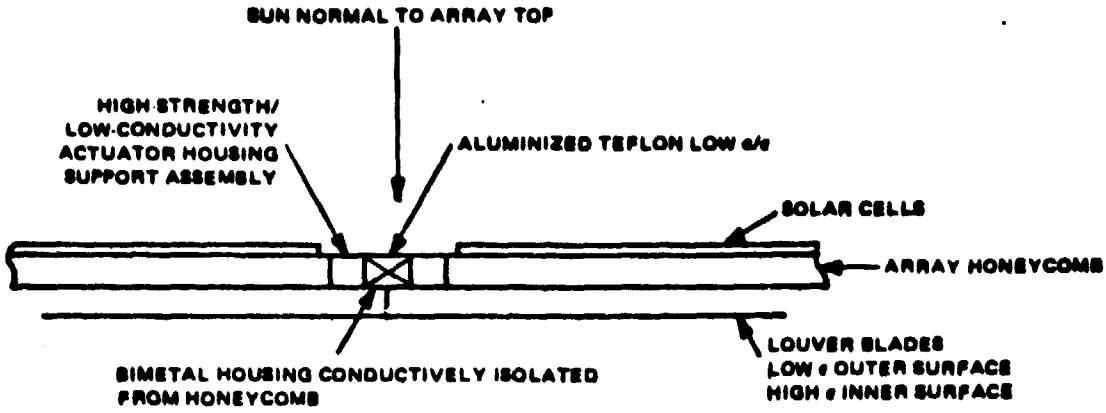


Figure 1. DE-A Louver Assembly Configuration

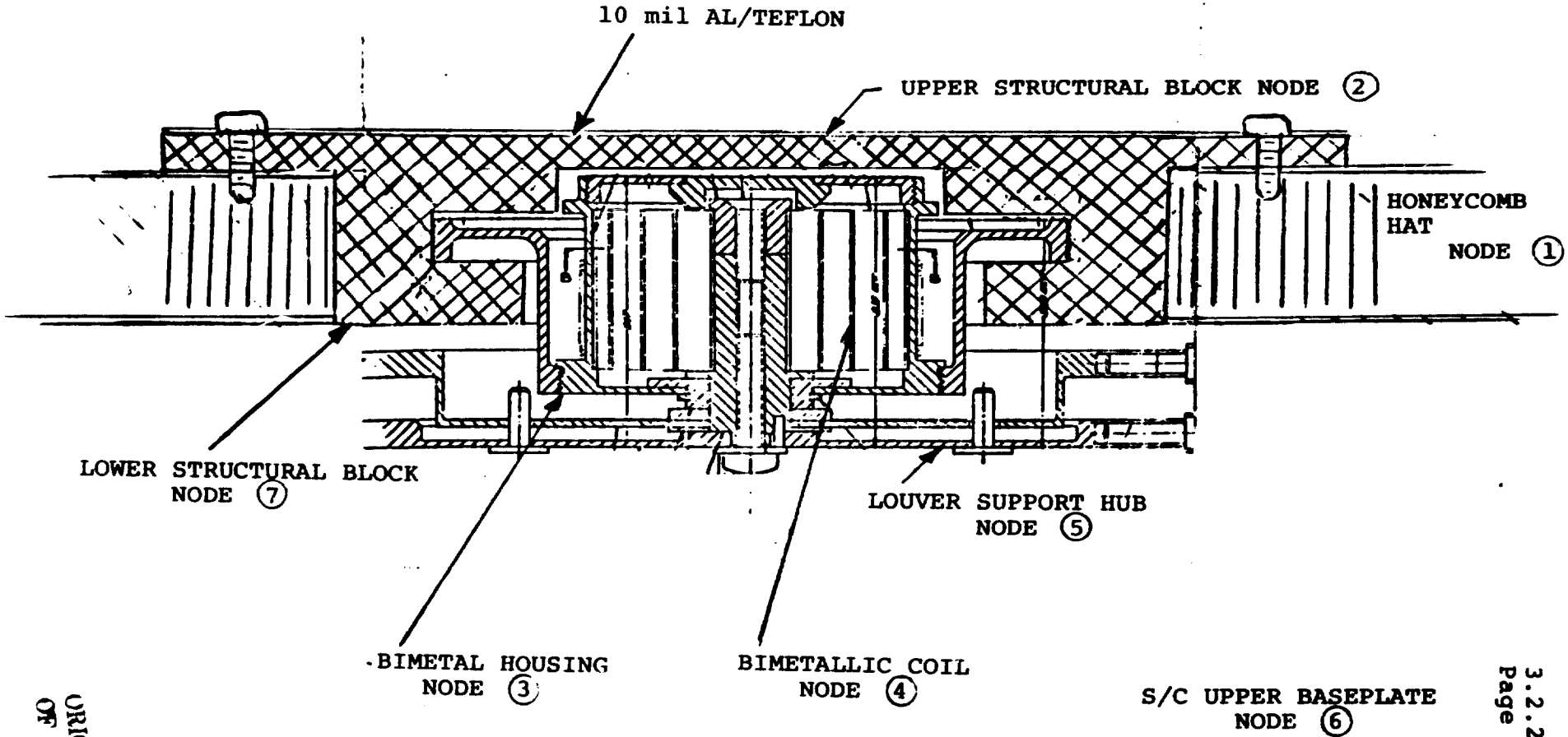


Figure 2. Bimetal Housing Mounted on Structural Support Block

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4. THERMAL MODEL AND PERFORMANCE

A 7-node simplified thermal model of the ATC assembly is described in Table 2 and Figure 2. Table 2 also lists the external sinks, of which the equivalent black body radiation values are given in Table 4. Table 3 lists all the internal and external radiation couplings and conductive couplings between the nodes. Two materials for the isolating structural block are considered to evaluate the parametric effect of conductance on the bimetallic coil temperatures. These two materials - Polycarbofil G50/40 and G11 Fiberglass/Epoxy - have different mechanical properties (See Table 1). The selection of one or the other (or similar other material) will be determined by thermal and mechanical requirements.

Assuming end solar array substrate (Honeycomb Hat) at 80°C and spacecraft-baseplate at 25°C (constant temperature nodes), the simplified thermal model predictions show that the bimetallic coil can be adequately cooled to about 31°C by higher strength G11 epoxy-fiberglass. Applying an uncertainty factor of $\pm$5°C results in a maximum coil temperature of 36°C.

If the louver passive set point is set at 40°C (above 36°C), then applying ΔT of 30°C to fully open the louver actively requires that the bimetallic coil be heated up to about 70°C which is an acceptable temperature of the bimetallic coil.

The data for the two materials of the structural block are plotted in Figure 3. Even though this is a simplified model of the ATC assembly, this model has indicated that it is possible to cool the bimetallic actuator housing and the coil to acceptable levels. The extended model will address to the following details:

a) Gradients through the structural block;

b) Accurate values of conductive couplings across the joint between substrate and housing;

c) Heater requirements for the normal louver operation.

FIGURE 3

DEPENDENCE OF ATC ELEMENTS TEMPERATURE ON THE CONDUCTANCE OF THE SUPPORTING STRUCTRAL BLOCK

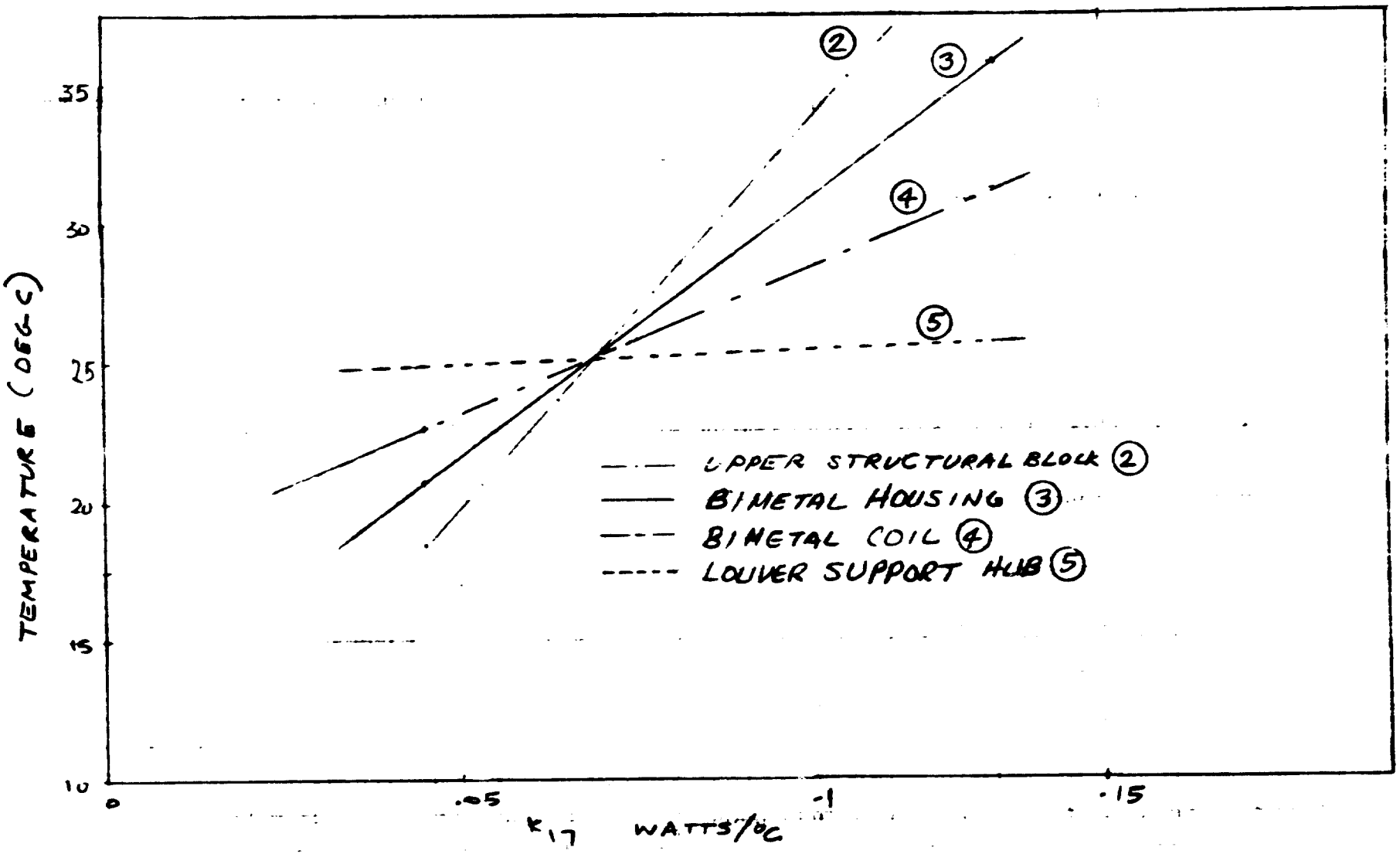


TABLE 2. IDENTIFICATION OF NODES AND EXTERNAL SINKS

NODE	DESCRIPTION
1	Honeycomb Hat
2	Upper Structural Block
3	Bimetal Housing
4	Bimetal Coil
5	Louver Support Hub
6	Baseplate
7	Lower Structural Block
SINK	**DESCRIPTION**
1	ATC Cold Patch
2	Space

TABLE 3. ATC COUPLINGS

Internal Couplings							External Coupling
		Radiative Coupling	Conductive Coupling Structural Block (w°/C)				Radiative Coupling
From	To	(in^2)	G50/40	G11 Structural Block	From	To	(in^2)
1	2	.016	.001	.001	1	2	1000.(1)
1	7		.023	.125	2	1	9.927
2	3	.022	.002	.002	6	2	1000.(2)
2	7		.0085	.046			
3	4	.112	.002	.002			
4	5	.001	.002	.002			
5	6	5.500					
5	7	.010					

(1) Together with Q_1 = 568.9W to keep T_1 = 80°C (Constant Temperature Node)

(2) Together with Q_6 = 289.3W to keep T_6 = 25°C (Constant Temperature Node)

TABLE 4. EXTERNAL SINK VALUES

SINK	SINK EQUIVALENT BLACK BODY RADIATION Watts/in^2
	BOL. 18 DEGREE SUN ANBLE
1	.222
2	0

TABLE 5. THERMAL PERFORMANCE OF ATC
18° SUN ANGLE, BOL

TEMPERATURE ~°C

NODE	STRUCTURAL BLOCK MATERIAL		COMMENTS
	G50/40	G11	
1	80°C	80°C	Constant Temp Node
2	18.4	41.0	
3	20.7	35.7	
4	22.6	31.2	
5	24.9	25.7	
6	25.0	25.0	Constant Temp Node
7	64.4	69.4	

5. DISCUSSION

It is shown that the louver bimetallic spring can be cooled to 36°C by incorporating a structural block between the actuator housing and the end solar array substrate, along with a cold patch on the block facing the space to locally cool the area. Following scenarios for the DE-A louver operation are offered:

a) When sun is incident on a louver side, the louver heater on that side will be deactivated by ground command and the louver will be closed. This type of operation requires that the passive opening point (set-point) of the louver be set at a temperature higher than the housing's maximum equilibrium temperature. The bimetal housing achieves a maximum equilibrium temperature of 36°C for worst-case conditions, then, to remain closed, the passive opening temperature must be set higher than 36°C . The passive set-point is an important parameter in the louver design, since it dictates the amount of heater power required to open the louvers when louver operation is desired (the higher the passive set-point, the higher the required power to open the louvers). Also, since the bimetal must be elevated to a temperature higher than the set-point (~30°C higher) to fully open the louver, the actuator housing and the bimetal will be qualified to temperatures up to 80°C.

b) When the sun is not incident on a louver side, the louver on that side will operate normally as a function of the baseplate temperature. To open, TCE will activate the bimetal heater, elevating the bimetal temperature until the louver is in a full-open position. This operation is similar to the Atmosphere Explorer louver-system operation. Since the passive set-point is set to satisfy scenario (a), the louver heater will have to drive the bimetal to a temperature approximately 30°C higher than the passive set-point while in a worst-case cold (no sun on hat) environment.

The emittance characteristic of the outside of ATC assembly facing the space has not been substantially altered by the design change. Although not analyzed here, the cold case simulation of the nominal louver operation will not result in much too different temperatures for the actuator housing than that for the Atmosphere Explorer. If anything, the situation is better with a structural insulating block between the actuator housing and the cold end array substrate, which will maintain the housing and the bimetal temperatures higher than those achieved for the Atmosphere Explorer design.

Hence, even though the passive set point of the louver dictated by scenario (a) may be higher than that for the Atmosphere Explorer louver design, the total temperature differential required to fully rotate the bimetal would be about the same, resulting in similar heater power requirements.

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 3.2.2-009-DN

Title

Thermal Interfaces for Booms and Antennas for the DE-A and DE-B Spacecraft

Written by: C. Chhatpar	Date Oct. 13, 1978
Approved by: W. V. Fuldner	Date Oct. 13, 1978
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

Letter	Description	Date	Author

Standard Distribution:
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D. Shipley

1. Summary

Current status of the boom and antenna designs are in the preliminary stage where only overall location information is available. The mechanical design has not progressed enough to yield a reasonable thermal model. However, preliminary thermal analysis has been carried out that specifies certain interface temperature requirements, external surface finish requirements and auxiliary heater requirements when the design is biased towards a cold operational performance.

2. Assessment of Design Requirements

2.1 MAG on Astromast Boom (DE-A and DE-B) Interface at MAG

Memo of Jim Marshburn, GSFC/NASA, dated July 3, 1978 specifies a .3 watt custom design heater bonded to the inside of the magnetometer mounting plate to maintain the MAG-A between 18°C and 27°C and MAG-B between 18°C and 35°C with booms between -40°C and +40°C respectively. This design also requires that the Mag mounting plate be isolated from the magnetometer base by use of titanium spacers and Delrin washers.

Since the magnetometer shadows the mounting plate for all the sun angles, a VDA finish for the mounting plate is recommended to minimize the radiation coupling between tne two.

2.2 Astromast Interface at Spacecrait (DE-A and DE-B)

The Astromast housing is recessed inside the spacecraft. When fully deployed, the housing will form a cavity susceptible to all external fluxes. The spacecraft baseplate interface will be running at 25°C (at 45° sun angle for DE-A) and 0°C (at 90° sun angle for DE-A). In the 90° sun angle case, this cavity could form a significant heat-leak which will be minimized by following design recommendations:

a) Backside of magnetometer housing will be fully blanketed.
b) The inside of the housing will be coated with specular VDA to minimize external flux absorption.

2.3 PWI on Astromast Boom (DE-A and DE-B)

The PWI and the stub boom on the Astromast do not shadow the mounting plate as much as the magnetometer does. In order to minimize the heat exchange across the mounting plate, the mounting plate will be covered with low α, high ε surface finish, in addition to it being isolated from the boom itself.

2.4 S-Band Antenna (DE-A)

The bracket hinge supporting this antenna will undergo following environment:

a) Antenna will be deployed prior to 70 rpm spin-up. As a result, it may see the initial sun angle of 108°.
b) In orbit, the bracket will see the extreme temperature swings of the end solar array from $-110^{\circ}C$ to $+80^{\circ}C$.
c) The hinge and the damper, while antenna is being deployed, should be between $0^{\circ}C$ and $20^{\circ}C$.
d) After antenna deployed, the bracket hinge and the damper temperature should not exceed $50^{\circ}C$ ($40^{\circ}C$ preferably).

These environment and temperature requirements dictate that the hinge-damper design will be biased towards cold end, with a small heater to keep the assembly near $0^{\circ}C$ under extreme cold conditions. The external finish configuration will consist of Goddard-white (NS43C) paint ($\alpha_{EOL} = .3$, $\varepsilon_{BOL} = .92$) in addition to certain areas with low ε finish.

3. Discussion

These conceptual thermal designs for the booms and the antennas are provided as guide lines for when the mechanical design starts to address to these details.

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 3.2.2-010-DN
Title: DE-A and DE-B Thermal Design Hardware Summary	
Written by: C. Chhatpar and P. Shang	Date: 10/6/78
Approved by: W. V. Fuldner	Date: 17 Oct 78
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

Letter	Description	Date	Author

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D. Shipley

1.0 Summary

To achieve temperature control of the spacecraft components during the DE missions, both Passive Thermal Control Elements and Active Thermal Control Elements are used. Because of the differences in the spacecraft operational modes and external thermal factors, individual designs are necessary to meet the mission requirements. This design note summarizes the design of thermal hardware, requirements for new hardware, areas of design difficulty for new hardware. Detailed descriptions of the thermal performances of the spacecrafts are given in 3.2.2-003 thru 006-DN.

2.0 Passive Thermal Control

Passive Thermal Control is obtained through careful selection of surface coatings, surface finishes, thermal conductive materials, thermal blankets, and thermal shields. Tables 1 and 2 list various coatings and finishes, and their application for DE-A and DE-B spacecrafts, respectively. Table 3 provides the characteristics of different thermal conduction control materials and locations at which they are used.

Thermal shields are used where protection from solar or aerodynamic heating is required. The thermal shields provided are a single layer of 2-mil second-surface aluminized Teflon, used to cover the separation-adapter open structure between the PWI booms and the separation ring at both ends on DE-A and at the bottom end on DE-B. These shields provide sun-shielding of the +z and -z end during on-orbit operation.

TABLE 1 DE-A THERMAL-CONTROL FINISHES AND COATINGS

Coating/Finish	Application	α		ε	
		Minimum	Maximum	Minimum	Maximum
Black Paint (Chemglaze Z-306)	Upper & Lower baseplate, shear webs, center-column, separation adapter external (except 4-in. wide polished aluminum section adjacent to hat flange), internal-equipment surfaces, transistor brackets, separation-adapter-well equipment surfaces inside well.	0.93	0.96	0.85	0.9
White Paint (Chemglaze Z-202)	Center-band antenna bracket	0.25	0.6	0.84	0.88
White Paint (IITRI S-13 GLO)	Upper-hat out-board finish except solar cells, lower-hat outboard finish except solar cells.	0.2	0.4	0.84	0.88
Second-surface aluminized Kapton sheet (0.05 mil) reinforced with Dacron Cloth	Upper-hat side in-board, lower-hat side in-board insulation blanket.	0.32	0.37	0.5	0.55
Buffed Aluminum	Separation ring, edges of ATC opening.	-	-	-	-
Polished Aluminum	Separation-adapter-well equipment exposed surfaces.	0.08	0.15	0.02	0.05
Second-surface aluminized Teflon sheet (2 mil)	Separation adapter well equipment exposed surfaces, thermal shield external.	0.13	0.2	0.62	0.67
Second-surface aluminized Teflon sheet (10 mil)	ATC cold patches	0.15	0.2	0.79	0.83
Goddard White Goddard Green	RIMS Ground Plane S-Band Antenna Bracket, bare-metal ground planes and areas*	0.2 to 0.6	0.3 to 0.7	0.92	0.92

* Electrically conductive paint to satisfy bare-metal area requirements with acceptable thermal properties.

TABLE 2 DE-B THERMAL-CONTROL FINISHES AND COATINGS

Coating/Finish	Application	α		ε	
		Minimum	Maximum	Minimum	Maximum
Black Paint (Chemblaze Z-306)	Upper and lower baseplates, shear webs, center-column, separation adapter external (except 4-inch wide polished aluminum section adjacent to hat flange), internal-equipment surfaces, lower-hat bottom in-board, transistor brackets, separation-adapter-well equipment surfaces inside well.	0.93	0.96	0.85	0.9
White Paint (Chemglaze Z-202)	Center-board antenna bracket.	0.25	0.6	0.84	0.88
White Paint (IITRI S-13-GLO)	Upper-hat outboard finish except solar cells, lower-hat outboard finish except solar cells.	0.2	0.4	0.84	0.88
Alternate black-chemglaze and gold-tape stripes	Upper-hat side in-board, lower-hat side in-board.	Controlled		Controlled	
Gold-tape/gold finish	Upper-hat top in-board, except ATC, ATC actuator housing outside.	0.19	0.25	0.02	0.05
Buffed Aluminum	Separation ring, edges of ATC opening.	-	-	-	-
Polished Aluminum	Separation-adapter-well equipment exposed surfaces.	0.08	0.15	0.02	0.05
Second surface aluminized Teflon sheet (2 mil)	Separation-adapter-well equipment exposed surfaces, thermal shield external.	0.13	0.2	0.62	0.67
Goddard White Goddard Green	Bare-metal ground planes, Astromast housing outside and areas*	0.2 to 0.6	0.3 to 0.7	0.92	0.92

*Electrically conductive paint to satisfy bare-metal area requirements with acceptable thermal properties.

TABLE 3 THERMAL-CONDUCTION-CONTROL MATERIALS

Material Type	Thermal Characteristics	Use Location
G11 Epoxy Fiberglass	Provides high thermal resistance to heat flow and high strength.	Bushings betwen separation adapter and bottom hat. Actuator housing support between top and bottom array and actuator housing on DE-A.
G50/40 Poly carbofil	Provides high thermal resistance.	Bushings between base-plates and hats.
Unprimed RTV	Improves thermal conductivity across high-power equipment mounting interface.	At mounting interfaces of transponder to base-plate.

Thermal Blankets

The application and construction of thermal-insulation blankets used on the spacecraft are given below. Blanket assembly and attachment to spacecraft surfaces are accomplished using urethane "button tacks", Velcro zippers, and tapes.

- Spacecraft-Side Outer Layer
  - Second-surface aluminized Kapton, 0.5 mil reinforced with Dacron cloth.
  - Inner Layers (10 layers).
  - Double-sided aluminized Mylar, 0.25-mil thick.
  - Separators (11 layers).
  - Dacron net, 1/8-inch honeycomb weave.
- Anti-Spacecraft-Side Outer Layer
  - Second-surface aluminized Kapton, 0.5 mil reinforced with Dacron cloth.

3.0 Active Thermal Control

Active Thermal Control Elements consist of heaters, louvers, and ATCE units. It is through the usage of these elements that the cooling and heating spacecraft components are achieved. In this section the heating elements and louvers used on the DE spacecrafts are briefly described.

Active Control Louvers

Four 20-inch diameter, double bladed, rotating vane, and bimetal actuated louvers (Figs. 1 and 2) which are similar to those on the AE spacecraft, are mounted on the antisun side of the spacecraft (Fig. 3), providing a radiation coupling to space which is variable. The louvers are actuated by a heating element located on the bimetal element housing. A sensor, located on the upper baseplate, is set to turn on the heater at a preselected temperature, driving the louver open. A louver system design almost identical to the AE spacecraft is applicable to the DE-B spacecraft.

The active thermal control hardware required for the DE-A spacecraft includes louvers (Fig. 4) on both ends of the spacecraft. The louvers (either end) are used in their normal mode (i.e., like DE-B) when they are not sun-illuminated, since DE-A will not perform a 180-degree rotation when the sun crosses the orbit plane; however, the sun will be incident on each side of the spacecraft at some point in the mission. Figure 5 shows the louver configuration when sun-illuminated. The ATC portion of the end solar array will achieve an average temperature of $80^{\circ}C$ when normally illuminated with the louvers closed. The primary design concern is one of effective isolation and cooling of the bimetal housing when its side of the spacecraft is illuminated. One design approach is to cover a portion (preferably a diameter concentric with the housing) of the hat with a low α/ϵ surface that will reduce the maximum temperature of the hat section immediately adjacent to the bimetal housing, resulting in a more desirable operating environment. This technique also relies on a relatively low conduction from the solar-cell-covered portion of the ATC part of the end solar array to the low α/ϵ covered portion via locally reduced skin thickness or low thermal-conductivity materials as shown in Figure 6. A preliminary thermal analysis shows that temperature of the isolated hat section surrounding the housing will be lower than $40^{\circ}C$ when the hat is at $80^{\circ}C$. The scenarios for DE-A louver operation are as follows:

(1) When sun is incident on a louver side, the louver heater on that side will be deactivated by ground command and the louver will be closed. This type of operation requires that the passive opening point (set-point) of the louver be set at a temperature higher than the housing's maximum equilibrium temperature. For example, if the bimetal housing achieves a maximum equilibrium temperature of $40^{\circ}C$ for worst-case conditions, then, to remain closed, the passive

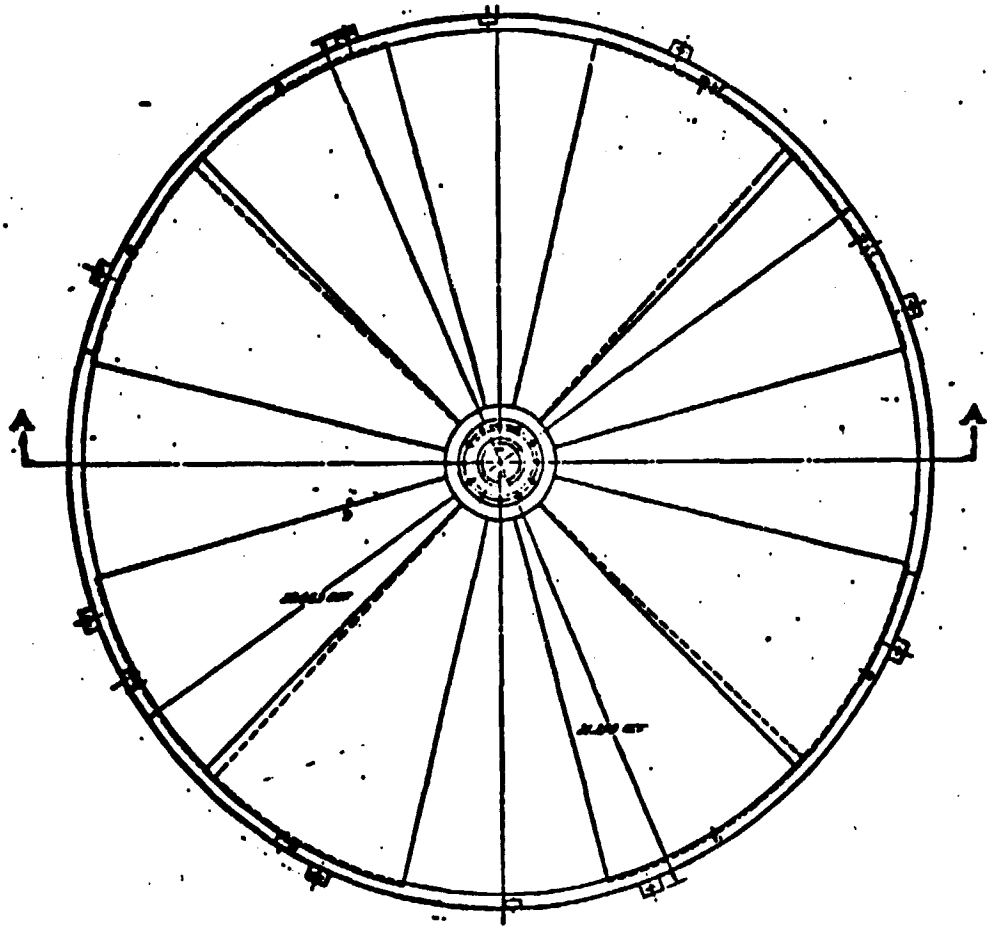


Figure 1. Louver Blade Configuration (From AE)

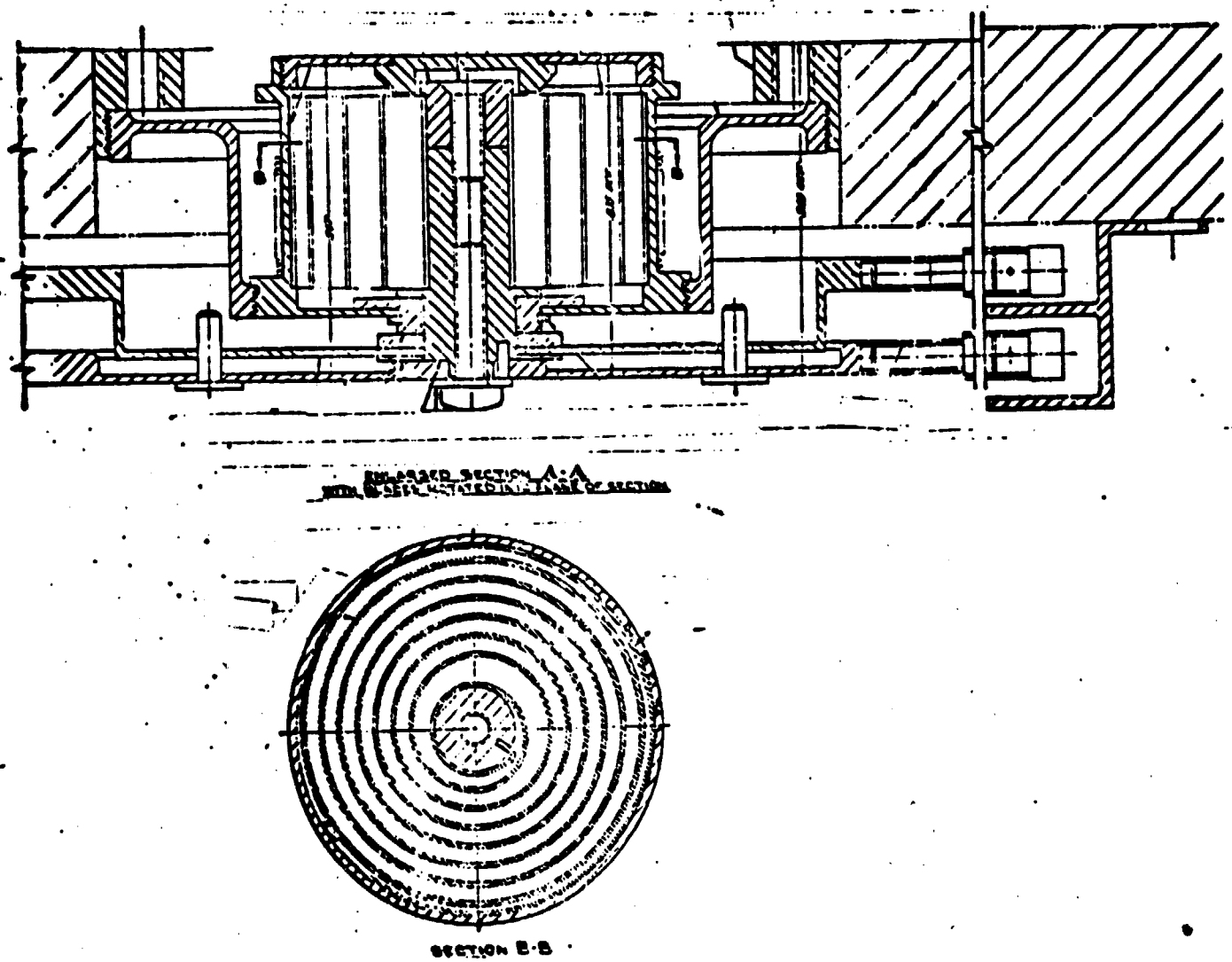


Figure 2. Bimetal/Housing Configuration (From AE)

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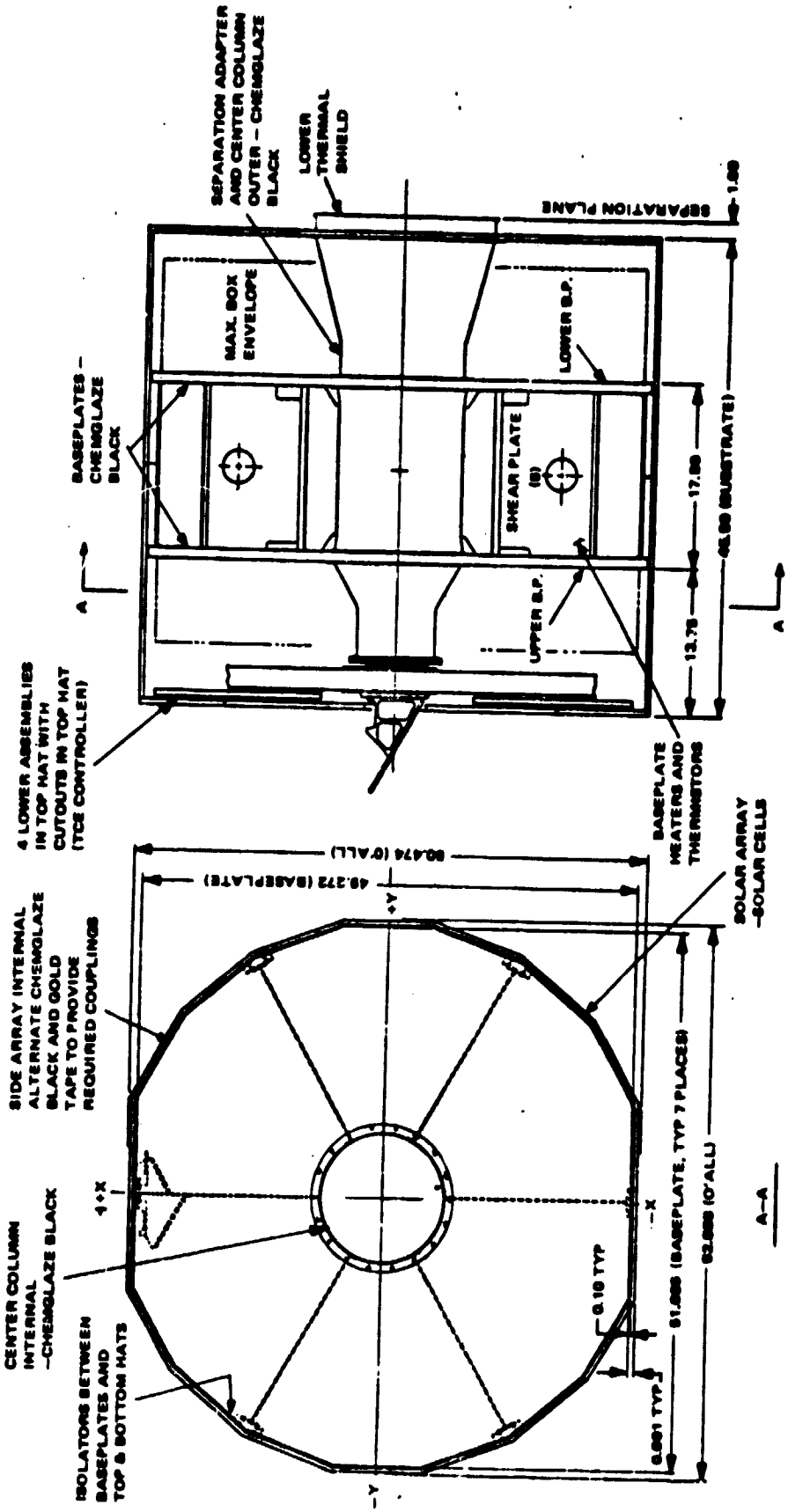


Figure 3. DE-B Thermal Configuration

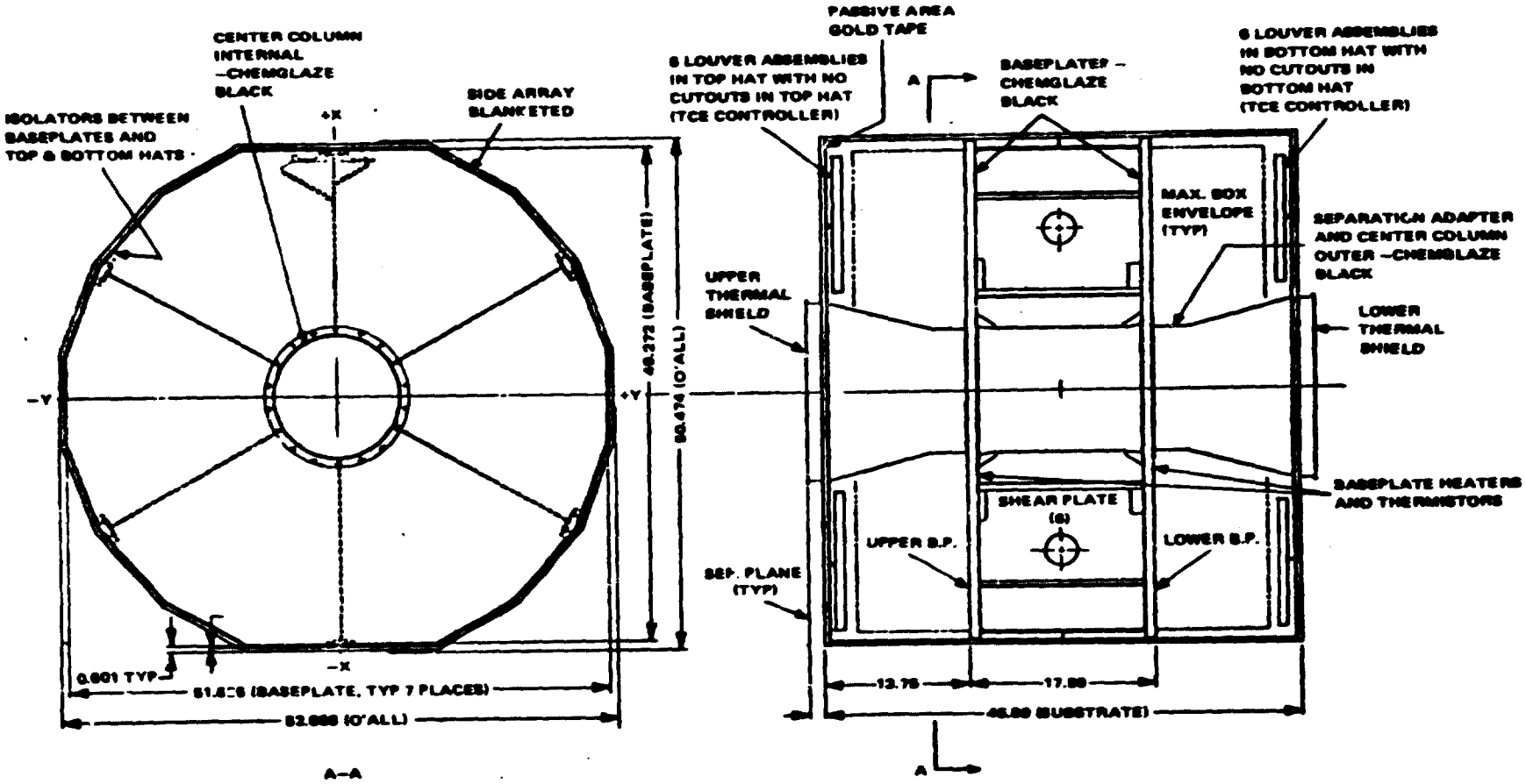


Figure 4. DE-A Thermal Configuration

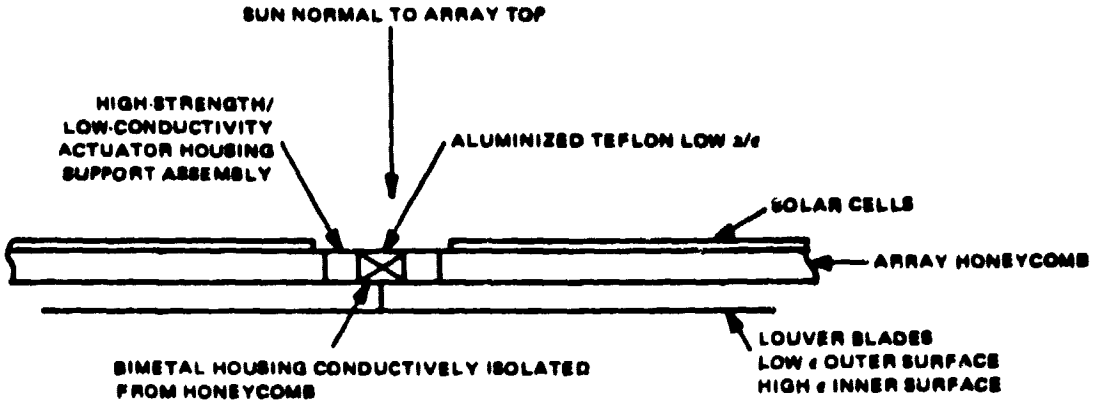


Figure 5. DE-A Louver Assembly Configuration

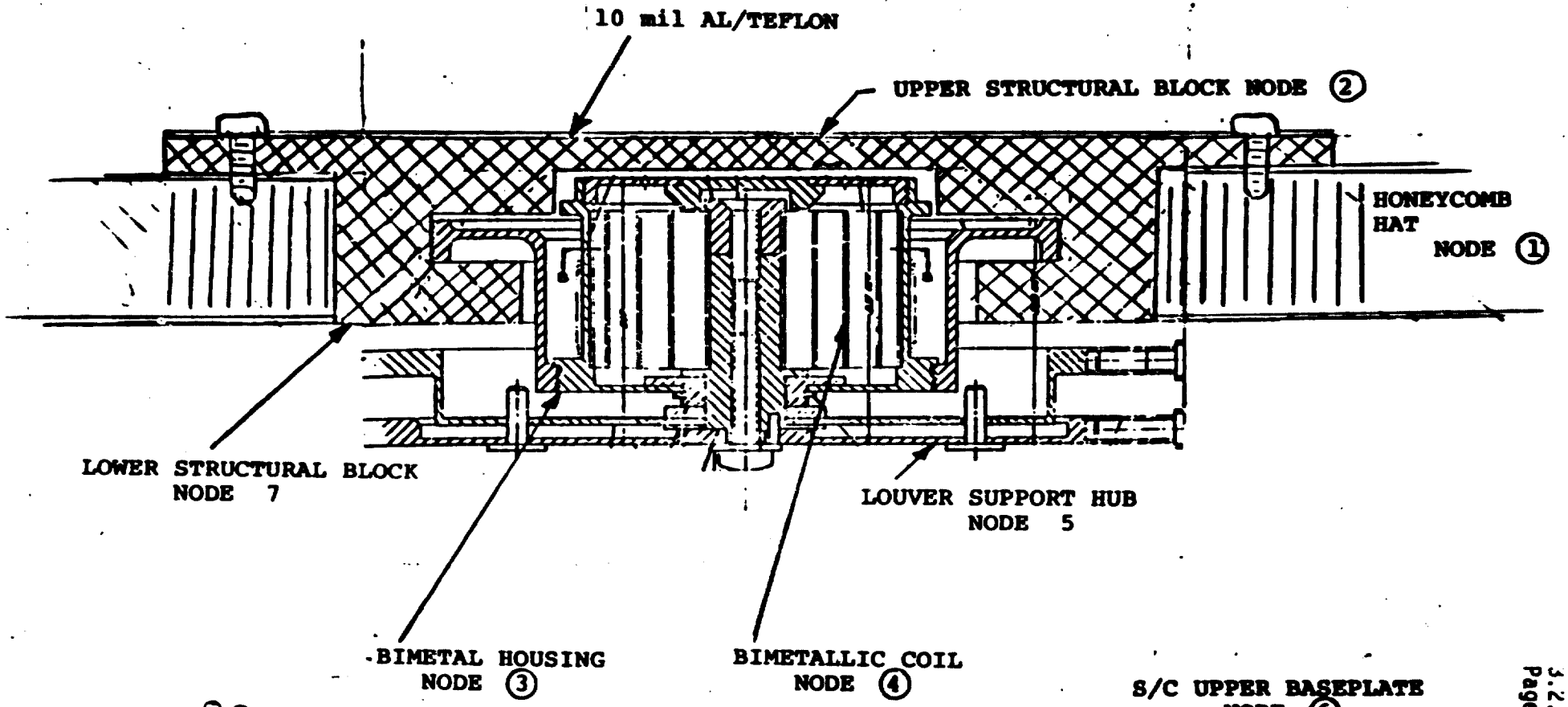


Figure 6. Bimetal Housing Mounted on Structural Support Block

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opening temperature must be set higher than 40°C. The passive set-point is an important parameter in the louver design, since it dictates the amount of heater power required to open the louvers when louver operation is desired (the higher the passive set-point, the higher the required power to open the louvers). Also, since the bimetal must be elevated to a temperature higher than the set-point (≈30°C higher) to fully open the louver, the activator housing and the bimetal will be qualified to temperatures up to 80°C.

(2) When the sun is not incident on a louver side, the louver on that side will operate normally as a function of the baseplate temperature. To open, TCE will activate the bimetal heater, elevating the bimetal temperature until the louver is in a full-open position. This operation is similar to the Atmosphere Explorer louver-system operation. Since the passive set-point is set to satisfy scenario one, the louver heater will have to drive the bimetal to a temperature approximately 30°C higher than the passive set-point while in a worst-case cold (no sun on hat) environment. If a louver design similar to the Atmosphere Explorer design is used, the required louver heater power will be higher than the Atmosphere Explorer louver power. A decrease in louver heater power is possible by employing a current TIROS-N design in the bimetal/heater area. The design consists of bonding the heating element directly to the bimetal coil rather than the housing surrounding the coil as was done for Atmosphere Explorer. The advantages of this design are increased-temperature response of the louver and more direct heating of the bimetal coil with reduced bimetal heater-power requirements.

Active Control Heaters

Heater elements characteristics are summarized in Table 4. This thin film strip-type heater has been successfully used for body heating as well as for the louver bimetalic drive.

TABLE 4 THERMAL-CONTROL-HEATER CHARACTERISTICS

Parameter	Characteristics
Insulation Materials	Kapton/FEP
Heater Element	Non-inductive, nichrome or cupronickel
Heater Leads	24 or 30 AWG stranded, Kapton insulated*
Heater Thickness	0.010 inch maximum, except 0.065 inch maximum over leads
Lead Length	12.00 inches minimum
Lead Pull Strength	3.0 pounds minimum
Heater Bend Radius	0.1-inch radius or greater
Insulation Resistance	1000 Megohms minimum at 500 Vdc
Temp Range: Operating Non-Operating	$-200^{o}C$ to $232^{o}C$ $-200^{o}C$ to $260^{o}C$
Power Density	Up to 70 watts/square-inch when properly heat sunk
Weight	Less than 0.25 gram per square-inch
Finish	Aluminum foil on bonded side
Heat Distribution	Uniform

*Bimetal heaters have Teflon insulation.

5.0 POWER SUBSYSTEM DESIGN NOTES

TABLE OF CONTENTS

Design Note	Title
3.4.2-005-DN	DE Array Design Considerations
3.4.2-006-DN	Shadowing of Solar Cells

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 3.4.2-005-DN

Title

DE Array Design Considerations

Written by: P. Nekrasov	Date
Approved by: W. Fuldner	Date 13 Oct 78
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

REVISIONS

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CONTENT

1.0 Introduction

2.0 Tentative Conclusions and Future Effort

3.0 Assumptions and Ground Rules

4.0 Nomenclature and Numerical Assumptions

5.0 Analysis and Discussion

- 5.1 The NOVA Cell
  - 5.1.1 Description
  - 5.1.2 Characteristics
  - 5.1.3 Radiation Effects
  - 5.1.4 Cell Performance Analysis
    - 5.1.4.1 Series String Voltage Requirement
    - 5.1.4.2 Solar Cell Equations
    - 5.1.4.3 Solar Cell Performance Plots
  - 5.1.5 Confidence Level
- 5.2 Cover Glass Thickness
  - 5.2.1 Summary
  - 5.2.2 Analysis
- 5.3 Array Design Analysis
- 5.4 Series Cell Requirements and Protection Against Shadowing
- 5.5 DE-B Side Array Preliminary Layout Considerations

6.0 References

Appendix: Amount of Power Lost if Elements of a String of Series-Connected Solar Cells are Placed on Adjacent Panels of a n-Sided Configuration.

1.0 Introduction

This Design Note covers preparatory work necessary to begin solar cell layout and, ultimately, to determine the required number and size of solar cells as well as the solar array power.

Solar cell analysis performed for the DE program to date has been updated to reflect the NOVA cell technology. Series cell requirements and cell current availability have been computed for the radiation regime of the DE orbits. The 30-mil fused silica glass thickness has been found to offer nearly as much protection as the 60-mil thickness considered previously, with the added benefit of a sizable weight reduction. Preliminary layout considerations concentrate on preservation of the 2 X 2 cm cell size as a potential manufacturing cost advantage and to preserve legacy established on another RCA program; further work, however, is required in this area. The side array of the DE-B spacecraft has been used as the "driver" in the tradeoff analyses as the array portion most in need of power enhancement.

Shadowing loss protection analysis has been limited to an allowance for an increased number of series solar cells as in prior analyses.

2.0 Tentative Conclusions and Future Effort

Use of the NOVA solar cell with a non-optimized cell layout results in an end-of-life minimum Science ON Time duty cycle of 16 percent. An increase in the DE-B side array power of approximately eight percent raises the minimum duty cycle value to just above the required 19 percent minimum value (Table III, text). A potential increase of in excess of the required eight percent is possible if the DE-B side array maximum temperature, particularly the top "hat" portion, can be reduced from +67°C to +58°C or lower and if the elements of certain series cell strings are mounted on adjacent panels of the "B" array; the 2 x 2 cm cell size would be preserved in that case (part 5.5, text).

Immediate future plans include the performance of a cell layout, particularly on DE-B, to verify and finalize the tentative conclusions reached thus far as well as to define the cell quantity and characteristics (if different from the NOVA program) to initiate procurement.

3.0 Assumptions and Ground Rules

3.1 Nominal solar cell performance characteristics will be used in DE solar array design.

(a) solar intensity seasonal variation is neglected; during the summer and winter solstices, the solar cell current will be lower than presently reported by approximately 3.4 percent; during equinoxes, it will be higher by a like amount.

(b) prediction and measurement uncertainties, of the order of a total of $\pm$2%, are neglected.

3.2 Shadowing losses due to antennas, booms, and other appendages are fully compensated in DE solar arrays provided that the number of series cells is at least 10% greater than that required if no shadows were present.

3.3 The side array portion of the DE-B bottom array "hat" is not subject to shadowing by appendages.

3.4 Pending further solar cell layout work on DE arrays, present analysis is based on cell layout which is essentially the same as reported in References (5) and (8), except:
(a) the number of series cells is generally lower due to either the improved performance characteristics of the NOVA cell, or reduced temperatures (e.g., DE-A flat-end arrays), or both,
(b) minor re-adjustment in the number of paralleled series strings, e.g., reduced number of strings on DE-A flat-end arrays and two additional series strings on DE-B side; Table III, text.

3.5 Maximum solar cell steady-state temperatures are:

DE-A: side, +13°C
end array, +75°C

DE-B: side, +67°C
end array +110°C

3.6 The solar cell is identical to that specified in Reference (1), except as modified for cell thickness in this part 5.1.2(c) and with the addition of the palladium passivation layer, as per later quote (10/2/78) from the cell vendor.

4.0 Nomenclature and Numerical Assumptions

k_v solar cell voltage-temperature coefficient over linear range, in millivolts per °C rise. For NOVA cell (unirradiated), k_v = -2.23 mv/°C; reference (3)(a).

F_v factor applied to k_v to account for a change in its value as a function of irradiation level; Figure 1.

k_i solar cell current-temperature coefficient over linear range, in percent per °C rise. For NOVA cell (unirradiated) k_i = +0.063% per °C; Reference (3)(a).

F_i factor applied to k_i to account for a change in its value as a function of irradiation level; Figure 1.

T temperature, ^oC

$v_{mp}(T)$ maximum-power-point solar cell voltage at temperature T.

d_v non-time-variant degradation factor applied to solar cell voltage, with cell installed in a solar array; d_v = 0.99 (cell-to-cell wiring loss).

d_{rv} time-variant degradation factor applied to solar cell voltage, e.g., Figure 2.

$i_{mp}(T)$ maximum-power-point solar cell current at temperature T.

d_i non-time-variant degradation factor applied to solar cell current; for present purposes, the UV damage (0.97) and coverglass charged particle loss (0.97) will both be considered as fixed degradations. Product, d_i = 0.94.

d_{ri} time-variant degradation factor applied to solar cell current, e.g., Figure 2.

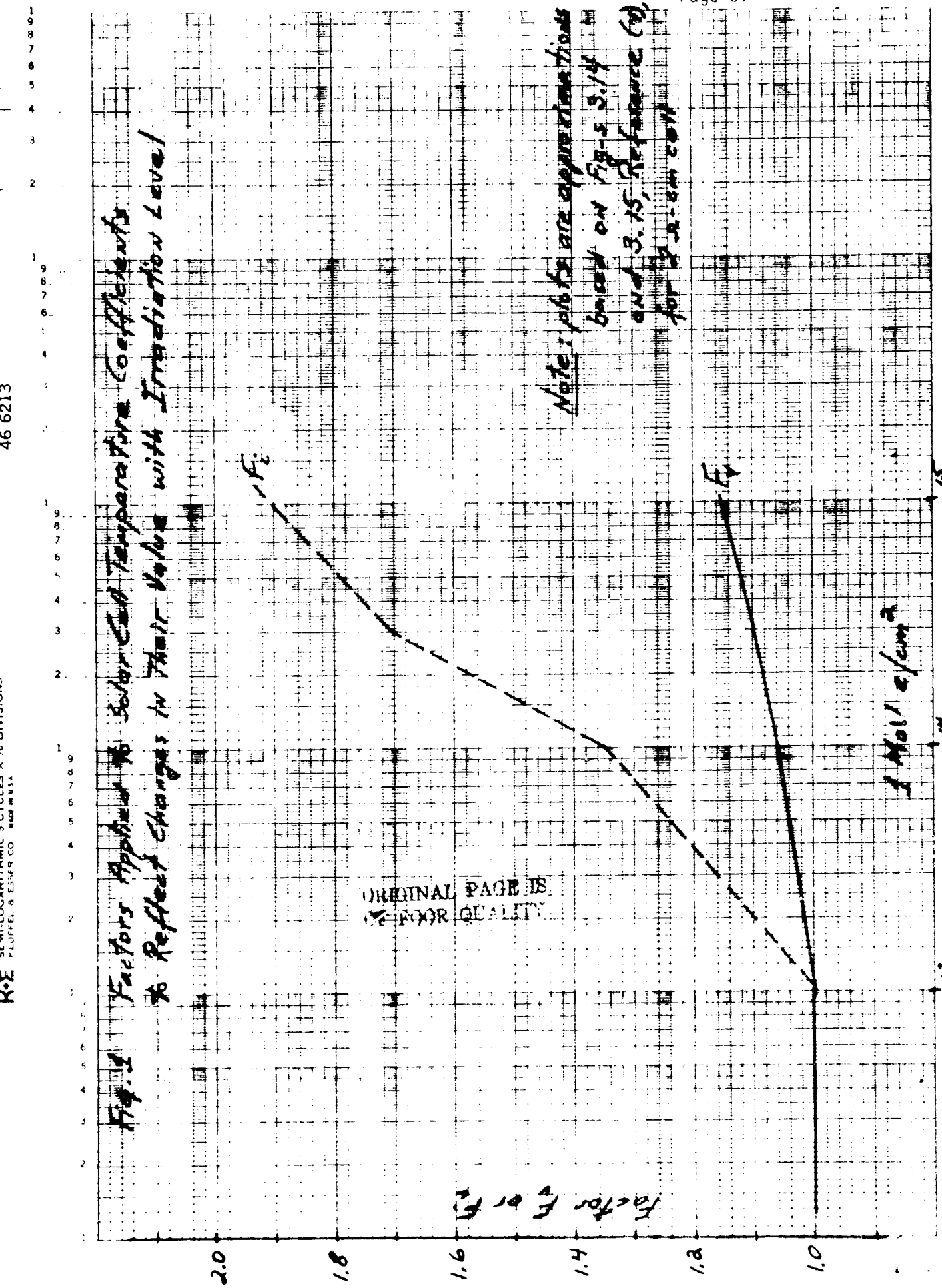
ΔV_{da} array blocking diode drop, 1.0 volt; Figure 3.

ΔV_{wi} array harness drop, 0.5 volts; Figure 3.

ΔV_{ch} charge regulator drop, 1.5 volts; Figure 3.

V_{BC} battery charge voltage assuming 1.45 volts per cell and 24 series storage cells; V_{BC} = 34.8V. Reference (5).

V_s voltage level (charge controller input) at which solar array power is computed, presently as well as in the DE Power Analysis Computer Program, Reference (7). V_s = 36.3 volts. Part 5.1.4.1.



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5.0 Analysis and Discussion

5.1 The NOVA Cell

5.1.1 Description

The solar cell most strongly considered for DE at the present time is the NOVA cell manufactured by OCLI. The DE cell, therefore, will be identical to that specified in Reference (1), with the possible exception of the cell dimensions which may have to be altered somewhat from the present 2 X 2 cm size to optimize the packing factor on DE, particularly on DE-B side. The cells would be ordered bare and coverglass bonded at RCA as under the NOVA program.

5.1.2 Characteristics

Given the 2 X 2 cm size, major characteristics of the NOVA-DE cell are:

(a) minimum average solar cell output, paragraph 3.11.2, Reference (1): 151 milliamperes at 0.49 volts, at +25°C AMO.

(b) base resistivity: 1-3 ohm-cm.

(c) cell thickness: 10 $\pm$2 mills (OCLI quote 2L78-78, Mod 2, 10/2/78).

(d) temperature coefficients, Reference (3)(a) unirradiated (see also Figure 1):

$$k_v = -2.23 \text{ mv}/^{o}\text{C}$$
$$k_i = +0.063\% \text{ per } ^{o}\text{C}$$

The above numerical characteristics form the basis for the analyses reported in this Design Note.

5.1.3 Radiation Effects

We are considering three different effects of space radiation on the power output of the NOVA solar cell. These are:

(1) Change in the values of the voltage and current temperature coefficients. The magnitude of the change in the values of cell voltage and current per unit temperature change is generally higher with increasing radiation levels. The approximate relationship used presently is given in Figure 1.

(2) Loss of light transmission through coverglass. A fixed 3% loss in cell current is assumed and included in the fixed current loss factor "d_i", part 4.0.

(3) Reduction in cell voltage and current. Figure 2 is a summary of the irradiation data examined to arrive at the cell degradation factors to be used in DE. Test data provided by OCLI in Reference (3) has been performed specifically for the RCA-NOVA program. Information plotted from Reference (4) is for a solar cell thought to be most nearly equivalent to the NOVA cell in performance; note that it is slightly on the pessimistic side as compared to the OCLI data.

Degradation factors chosen as design points for DE on the basis of the data examined are also shown in Figure 2.

5.1.4 Cell Performance Analysis

5.1.4.1 Series String Voltage Requirement

Ultimate objective is to connect a sufficient number of solar cells in series to assure full battery recharge. Reference is made to Figure 3. Voltage level V_s at the solar bus (charge controller input) must be equal to, or exceed slightly, the sum of the charge controller drop ΔV_{ch} and the voltage of a fully charged battery. The solar cell string voltage, "V(solar cells)" in Figure 3, must therefore equal

$$V(\text{solar cells}) = \Delta V_{da} + \Delta V_{wi} + \Delta V_{ch} + V_{BC} \quad (1)$$

$$= 1.0 + 0.5 + 1.5 + 34.8$$

$$= 37.8 \text{ volts}$$

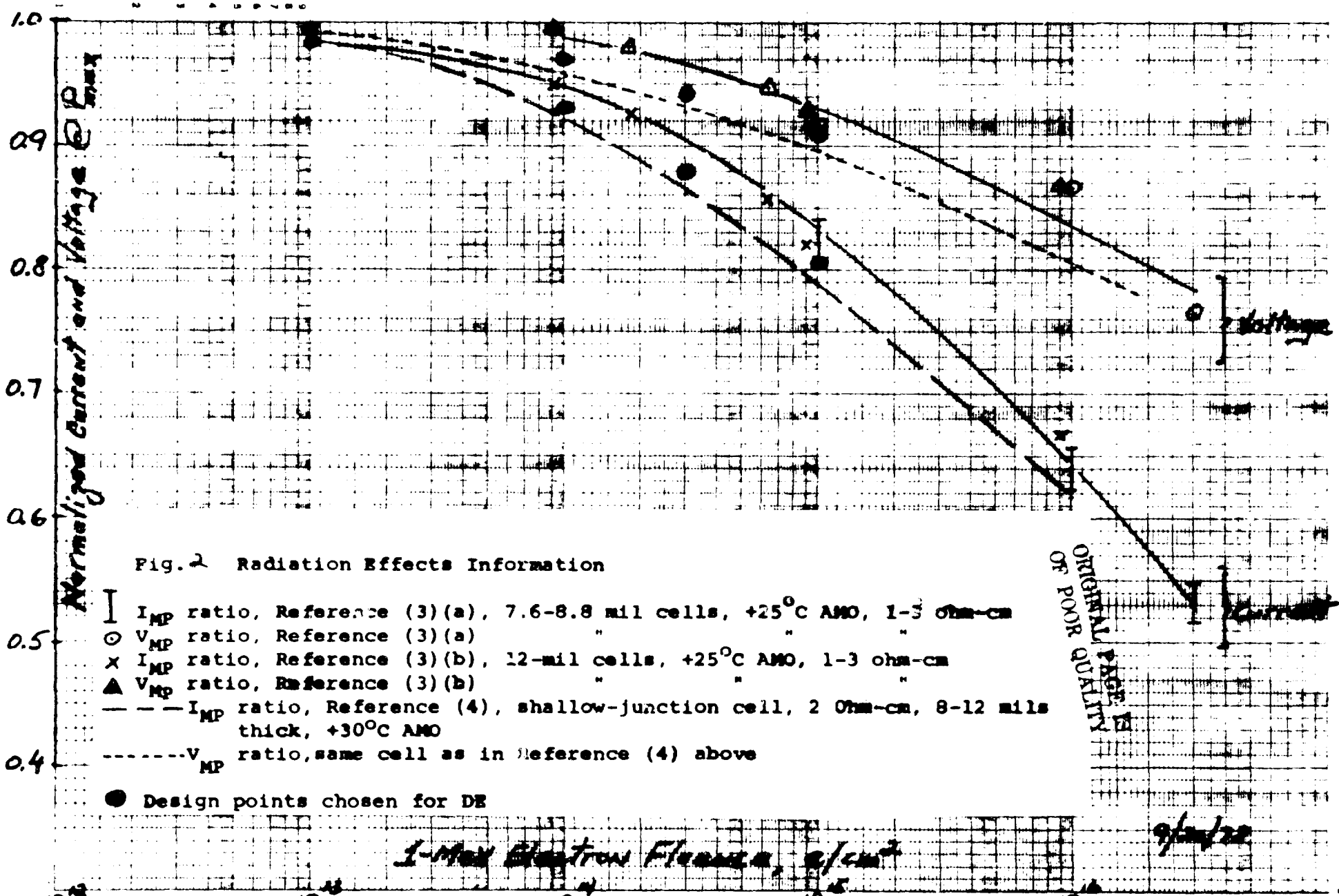


Fig. 2 Radiation Effects Information

I I_{MP} ratio, Reference (3)(a), 7.6-8.8 mil cells, +25°C AMO, 1-3 ohm-cm
⊙ V_{MP} ratio, Reference (3)(a) " " "
× I_{MP} ratio, Reference (3)(b), 12-mil cells, +25°C AMO, 1-3 ohm-cm
▲ V_{MP} ratio, Reference (3)(b) " " "
— — — I_{MP} ratio, Reference (4), shallow-junction cell, 2 Ohm-cm, 8-12 mils thick, +30°C AMO
------- V_{MP} ratio, same cell as in Reference (4) above

● Design points chosen for DE

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For future reference, note that the solar array output power P_s watts is computed at voltage V_s, which is

$$V_s = \Delta V_{ch} + V_{BC} = 36.3 \text{ volts} \qquad (2)$$

5.1.4.2 Solar Cell Equations

Location of the solar cell maximum power point at any temperature T within linear range, V_{mp} (T), i_{mp} (T), is given by

$$V_{mp}(T) = \left[V_{mp}(+25) + (T-25)F_v \cdot \kappa_v\right] d_{rv} d_v \qquad (3)$$

and

$$i_{mp}(T) = i_{mp}(+25)\left[1 + \frac{k_i}{100} F_i (T-25)\right] d_{ri} d_i \qquad (4)$$

where, for the NOVA cell, part 5.1.2(a),

V_{mp} (+25) = 0.490 volts,

i_{mp} (+25) = 151 ma,

and F_i, F_v, d_{ri}, and d_{rv} are quantities dependent on the irradiation level.

5.1.4.3 Solar Cell Performance Plots

Quantities $v_{mp}(T)$, i_{mp} (T) are computed using expressions (3) and (4) over a wide temperature range, and using irradiation level dependent quantities as tabulated in Table I.

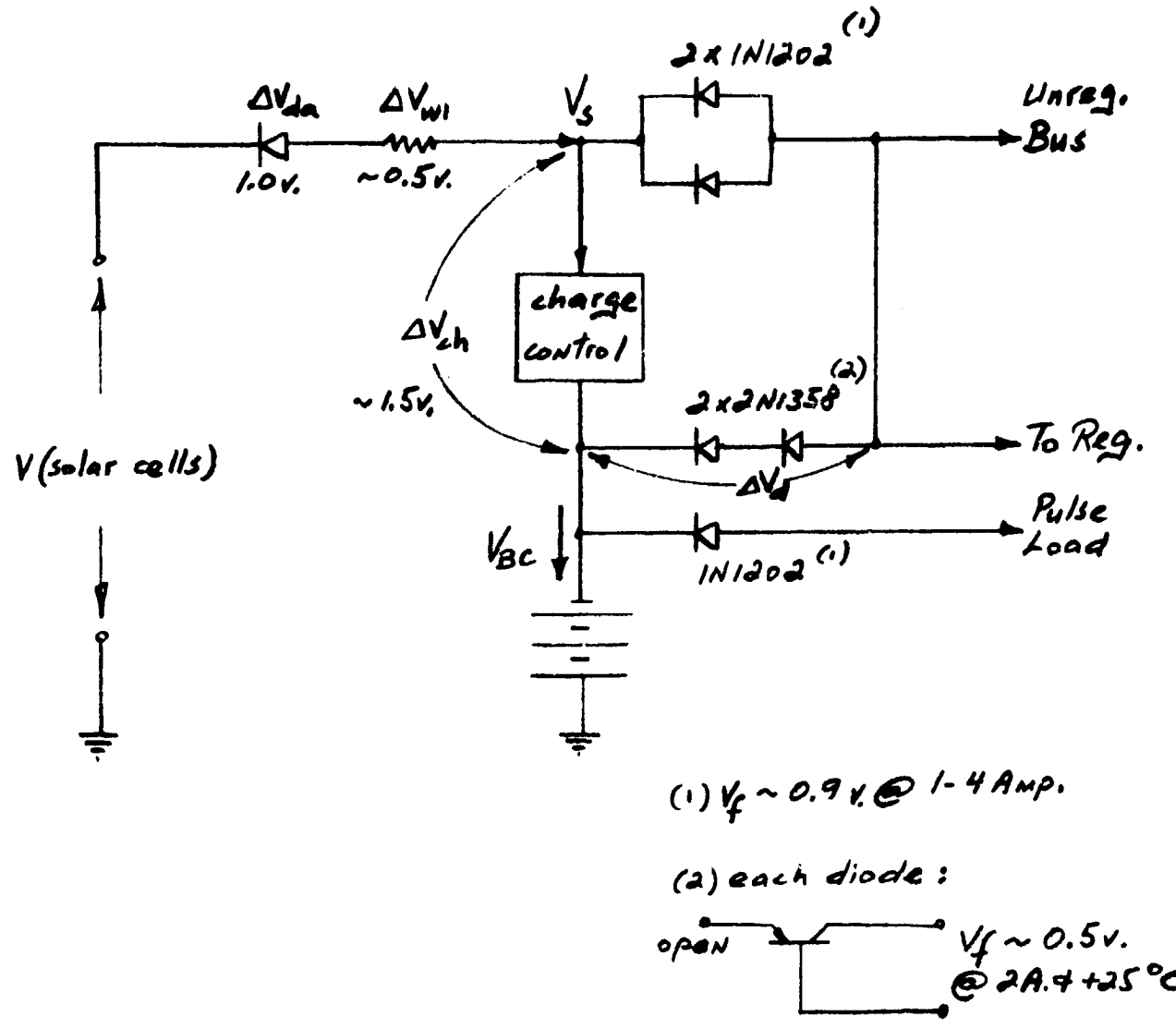


Fig.3 Solar Cell Series String Voltage Requirements

Fluence 1-MeV e/cm^2	d_{rv} (*)	F_v (Fig. 1)	d_{ri} (*)	F_i (Fig. 1)
10^{13}	0.99	1	0.98	1
10^{14}	0.97	1.06	0.93	1.35
3×10^{14}	0.94	1.10	0.88	1.7
10^{15}	0.91	1.15	0.81	1.9

(*) These factors are the "Design Points Chosen for DE", Figure 2.

Table 1. Irradiation Level Dependent Cell Parameters

Other numerical values used in eq-ns (3) and (4) as well as the meaning of all symbols are provided in part 4.0.

Computed quantities of $v_{mp}(T)$ are divided into 37.8 volts (part 5.1.4.1) and the result, the required number of series cells, is plotted in Figure 4 vs. solar cell temperature with the irradiation level retained as a parameter; computed quantities of i_{mp} (T) are plotted directly in Figure 5. Using the latter two sets of plots, a set of "working curves" is plotted for DE in Figure 6; here, we can see exactly what the cell voltage and current will do on various parts of DE arrays, depneding on what degree of protection (mils glass thickness, resulting in one or another value of "1 MeV e/cm^2") we choose to provide.

5.1.5 Confidence Level

The RCA NOVA cell specification, Reference (1), sheet 14, includes a plot of the radiation resistance requirement of that cell. We want to ascertain that our cell analysis performed thus far reflects performance which compares reasonably well with the specified minimum performance requirement.

We note that the curve on sheet 14 of the RCA specification is prepared for the condition of a bare cell at +60°C. Let one of our data points, say, at 10^{14} e/cm^2 (Figures 4 and 5) be reduced to the condition of the curve plotted in the spec:

(a) from Fig. 4, volts/cell at +60°C @ 10^{14} e/cm^2 equals 37.3/96.4 = 0.392 v.

(b) similarly, from Figure 5, ma/cell = 135.8 ma

(c) mw/cell = (0.392 v)x (135.8 ma); reducing this by 1% as is the case in an un-glassed cell, mw/cell = 52.7 mw. Reference (1), part 3.11.2.

(d) d_v = 1.00 (cell is not yet series-connected and as such has no "wiring drop"); 52.7/0.99 = 53.2 mw.

(e) d_i = 1.00 ("fixed" current loss, acquired only after launch, is zero); 53.2/0.94 = 56.7 mw.

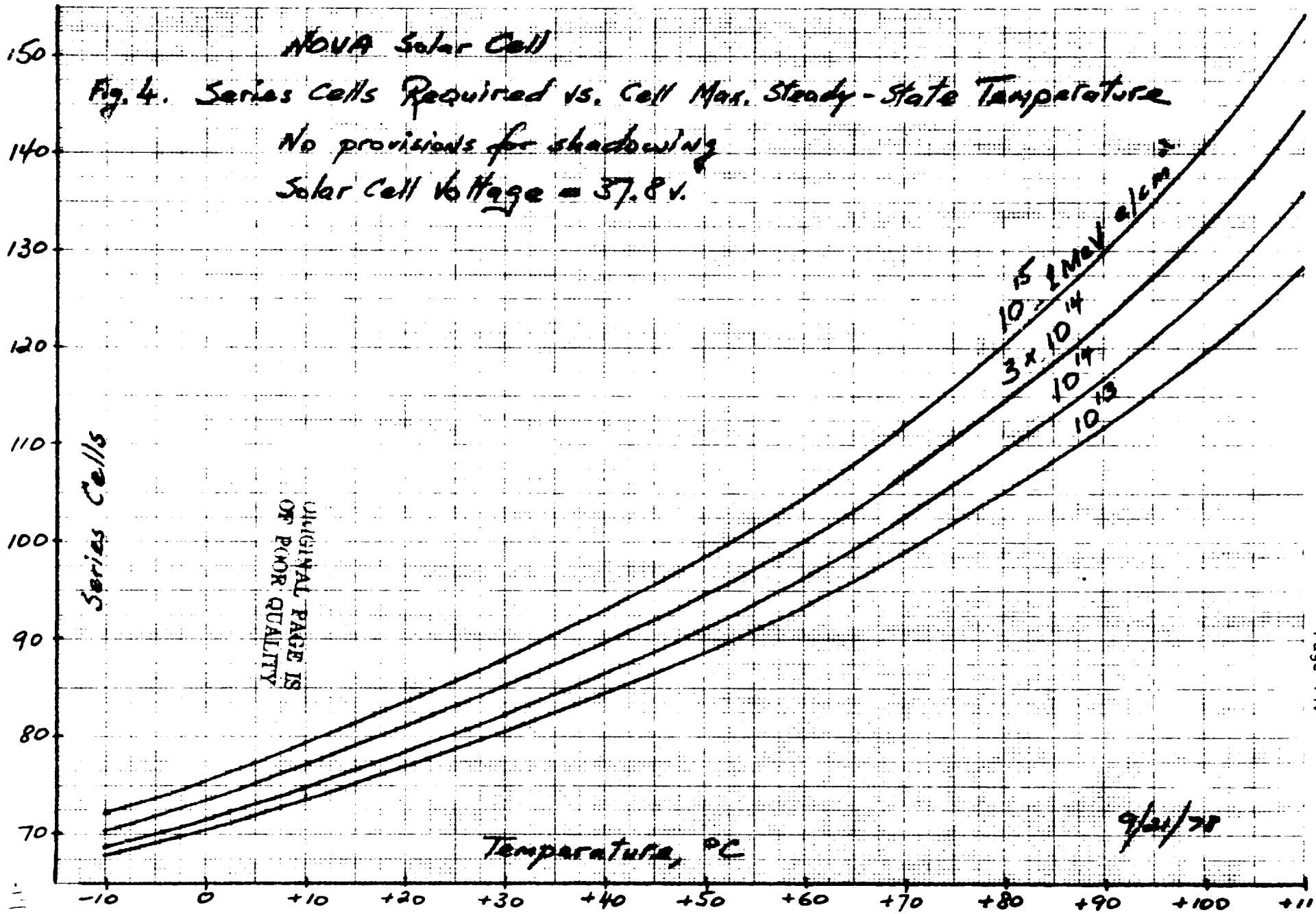
The latter value, 56.7 mw, compares well with 55 mw which is the minimum acceptable cell power at 10^{14} e/cm^2 1-MeV fluence. This and three other computed values are plotted on the curve from the RCA cell spec which is reproduced here in Figure 7. It is evident that the cell parameters being used presently for DE are based on cell performance which is just barely above the minimum acceptable procurement level and, as such, are reasonably "safe".

5.2 Cover Glass Thickness

5.2.1 Summary

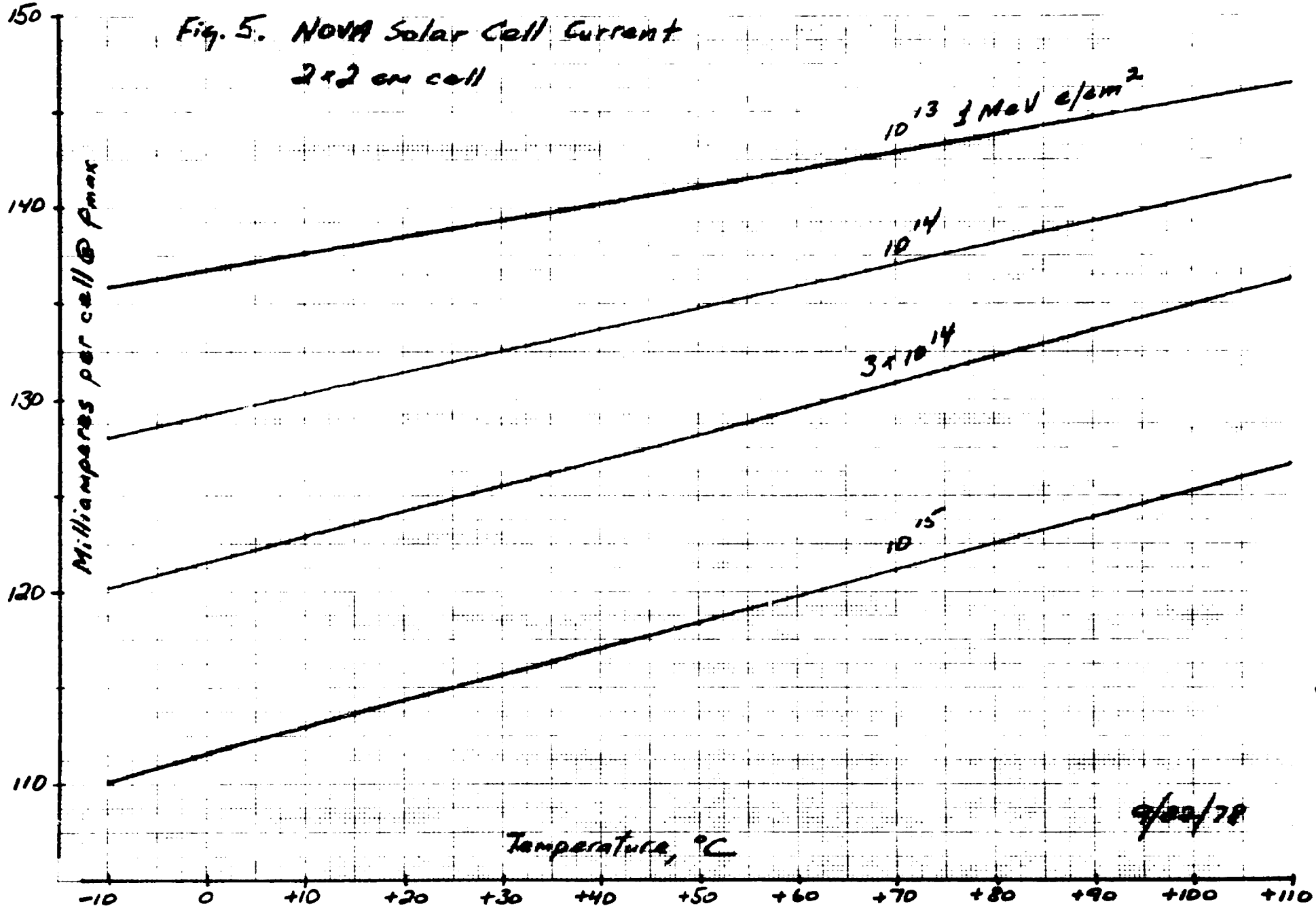
As pointed out in Reference (6), significant weight savings can be achieved if the fused silica cover glass thickness could be reduced from 60 to 30 mils on both DE spacecraft. Results of the analysis of the radiation environment in DE orbits, Reference (2), and the NOVA cell analysis reported in this part 5.1 provided the means for a cover-glass thickness tradeoff study as a result of which we find that the DE-B side array power suffers a loss of only one percent or less in going from 60 to 30 mils.

Discussion of the tradeoff analysis detail follows in part 5.2.2 below.



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Fig. 5. NOVA Solar Cell Current
2×2 cm cell



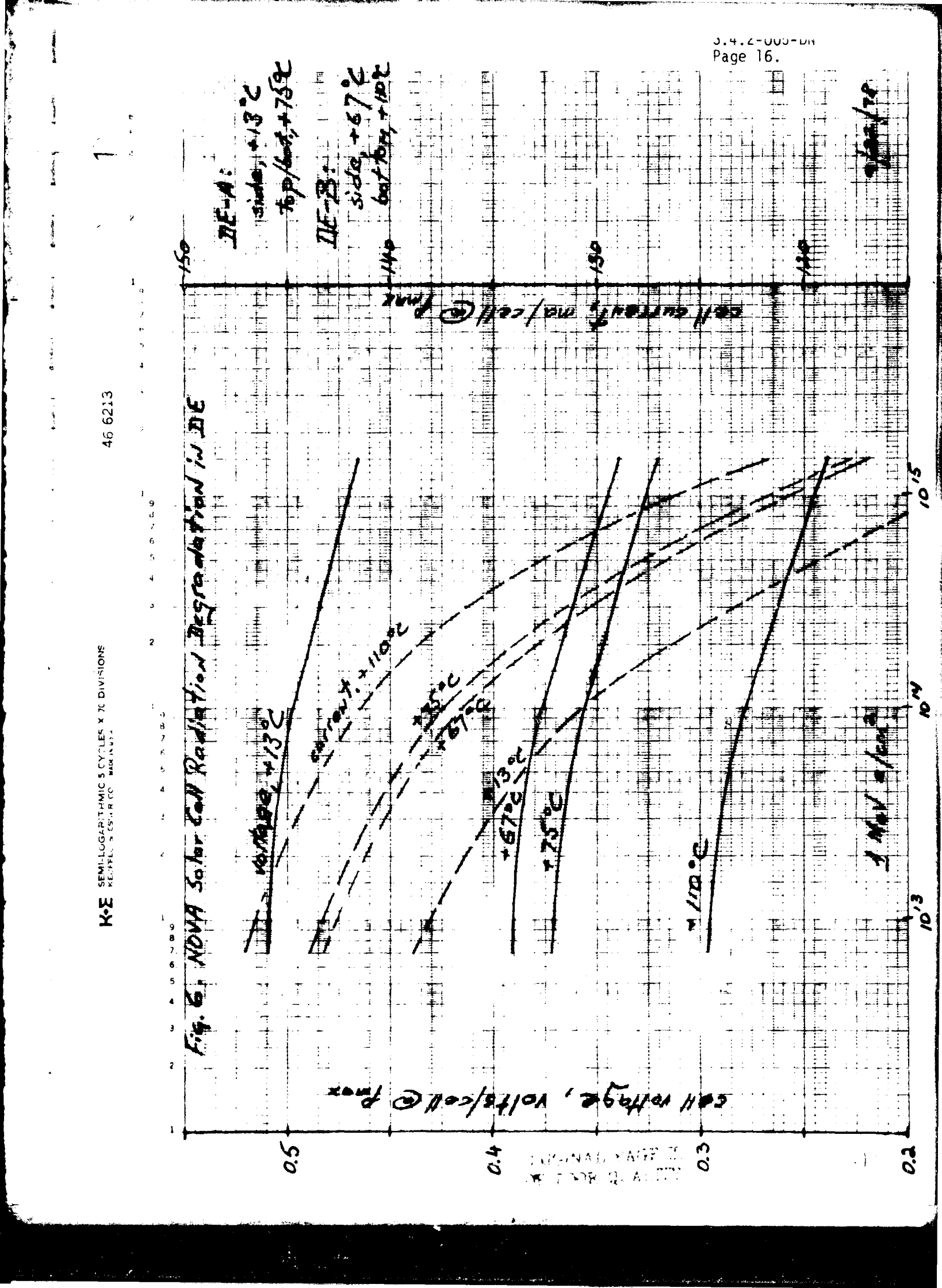
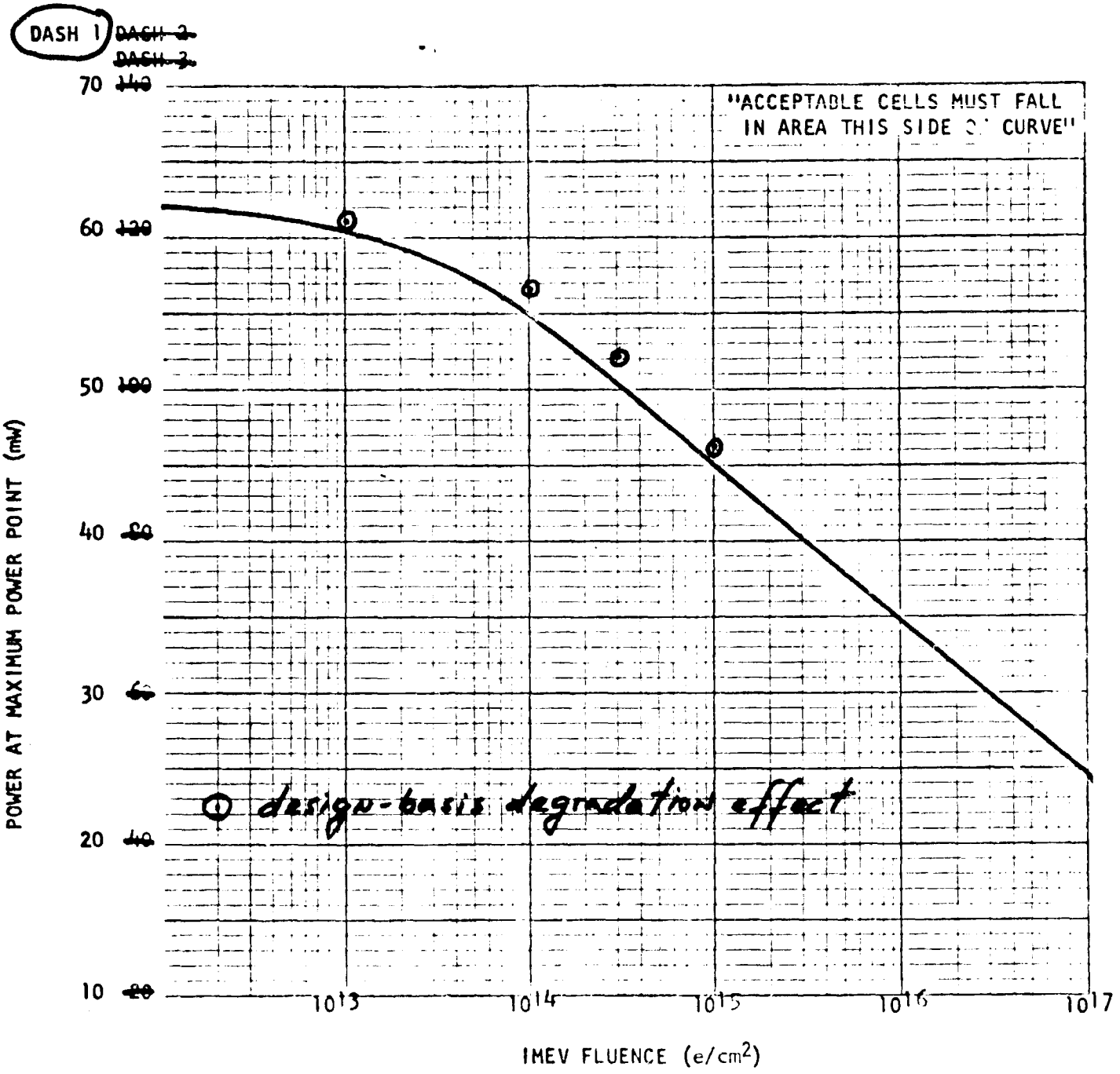


Fig. 6: NOVA Solar Cell Radiation Degradation in DE

K-E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213

Figure 7. Confidence Level



(Reference (1), Figure 1, Radiation Resistance Requirement Curve - Unglassed Cells at 60°C)

Size	Code Ident No.	
A	49671	2285464
		Sheet 14

AF 772 5/70

5.2.2 Analysis

Results of the glass thickness effects analysis are presented graphically in Figures 9 and 10. Most significantly, Figure 10 shows that increasing the glass thickness on the side array of DE-B beyond 30 mils does not produce an appreciable increase in EOL power.

Mechanics of the analysis is best described by reference to various columns (1 thru 12) in Table II. Let it be noted that this analysis is intended to be accurate only in a relative sense, and that great accuracies in the absolute numbers of watts per pound or per square foot quoted in Table II or in either Figures 9 or 10 are not to be expected.

Further discussion of the cover glass thickness as an array design parameter appears in part 5.3. Presently, reference is made to Table II:

Column	Rationale
1 and 2	Self-explanatory.
3	Maximum steady-state solar cell temperature.
4	Fused silica cover glass thickness.
5	Equivalent 1-MeV electron fluence for 13-month life, Reference (2).
6	From Figure 6.
7	Equivalent 1-MeV electron fluence for 13-month life, Reference (2).
8	From Figure 6.

Column	Rationale
9	Series cells required to locate the 13-month EOL maximum power point at 37.8 volts using per-cell voltage of Column 8. Plotted in Figure 8.
10	Using current and voltage given in colums 6 and 8, respectively, and assuming 204 2 x 2 cm cells per sq. ft. in a typical solar panel, the calculation becomes $\text{watts/sq. ft.} = 204 \frac{\text{cells}}{\text{sq.ft}} \times \frac{(\text{volts})(\text{ma})}{\text{cell}} \times \times 10^{-3} \frac{\text{w}}{\text{mw}}$ Note that with discrete bypass diodes mounted on array surface the number of cells per sq. ft. will be somewhat less than 204; for glass thickness trade-off purposes, however, consistency rather than absolute accuracy of the calculated watts/sq. ft. numbers is of primary importance.

Column	Rationale
	The calculated numbers are plotted in Figures 9 and 10.
11	Using fused silica coverglass areal density of 0.335 grams/cm^2 of 60-mil thickness, reference (4), Appendix A, page A-1, 204 2 x 2 cm cells per sq. ft. as in Column 10, 3.918 cm^2 coverglass area per 2 x 2 cm cell, and 0.45 pounds per sq. ft. of assembled solar cells exclusive of any cover glass, the pounds per sq. ft. calculation becomes $\frac{\text{pounds}}{\text{sq.ft.}} = 0.45 \frac{\text{lb}}{\text{ft}^2} + 204 \frac{\text{covers}}{\text{ft}^2} \times$ $\times (0.335 \frac{\text{gm}}{\text{cm}^2})(\frac{\Delta t}{60 \text{ mils}})(3.918 \frac{\text{cm}^2}{\text{cover}})(\frac{1}{453 \frac{\text{gm}}{\text{lb}}})$ $\frac{\text{pounds}}{\text{sq. ft.}} = 0.00985 \Delta t + 0.45$ where Δt = glass thickness, mils Note that the fixed quantity 0.45 lb/ft^2 is not precise, will vary with each array, and is not intended to include the substrate; for glass thickness tradeoff purposes, however, consistency rather than absolute accuracy of the calculated pounds/sq.ft. numbers if of primary importance.
12	The watts/pound numbers are calculated using columns 10 and 11, and plotted in Figures 9 and 10.

1	2	3	4	5	6	7	8	9	10	11	12
DE Flight	Array	Temp. °C	mils, glass	Cell Current		Cell Voltage		Series cells req'd	Watts / sq.ft	Pounds / sq.ft.	Watts / pound
				1 MeV e/cm^2	ma/cell	1 MeV e/cm^2	volts/cell				
A	side	+13	6	3×10^{15}	103.5	7×10^{15}	0.447	84.6	9.44	0.509	18.54
			10	1.4×10^{15}	109.4	3.3×10^{15}	0.455	83.2	10.16	0.548	18.54
			20	4.5×10^{14}	120	8×10^{14}	0.473	80	11.58	0.647	17.9
			40	1.9×10^{14}	127	2.7×10^{14}	0.485	78	12.57	0.844	14.89
			60	9.5×10^{13}	130.7	1.3×10^{14}	0.495	76.4	13.2	1.041	12.68
	top/bot.	+75	6	3×10^{15}	110	7×10^{15}	0.30	126	6.73	0.509	13.22
			10	1.4×10^{15}	118.5	3.3×10^{15}	0.31	122	7.5	0.548	13.68
			20	4.5×10^{14}	128.5	8×10^{14}	0.33	114.5	8.65	0.647	13.37
			40	1.9×10^{14}	134.3	2.7×10^{14}	0.343	110.2	9.4	0.844	11.14
			60	9.5×10^{13}	137.7	1.3×10^{14}	0.352	107.3	9.89	1.041	9.5
B	side	+67	6	1.3×10^{14}	135.3	2.5×10^{14}	0.364	103.8	10.05	0.509	19.74
			10	8.1×10^{13}	137.3	1.5×10^{14}	0.372	101.6	10.42	0.548	19.01
			20	4.6×10^{13}	139.1	6.9×10^{13}	0.381	99.2	10.81	0.647	16.71
			40	3×10^{13}	140.2	4×10^{13}	0.385	98.2	11.01	0.844	13.04
			60	2.2×10^{13}	141	2.6×10^{13}	0.387	97.7	11.21	1.041	10.77
	bottom	+110	6	1.3×10^{14}	140.5	2.5×10^{14}	0.265	142.6	7.6	0.509	14.93
			10	8.1×10^{13}	142	1.5×10^{14}	0.273	138.5	7.91	0.548	14.43
			20	4.6×10^{13}	143.5	6.9×10^{13}	0.283	133.6	8.28	0.647	12.8
			40	3×10^{13}	144.5	4×10^{13}	0.288	131.3	8.49	0.844	10.06
			60	2.2×10^{13}	145.1	2.6×10^{13}	0.291	129.9	8.61	1.041	8.27

Table II. Cover Glass Thickness Tradeoffs

Fig. 8. DE Series Cells vs. Glass Thickness
No shadowing effects
13-mo. Life
2/28/81 Launch
NOVA Cell

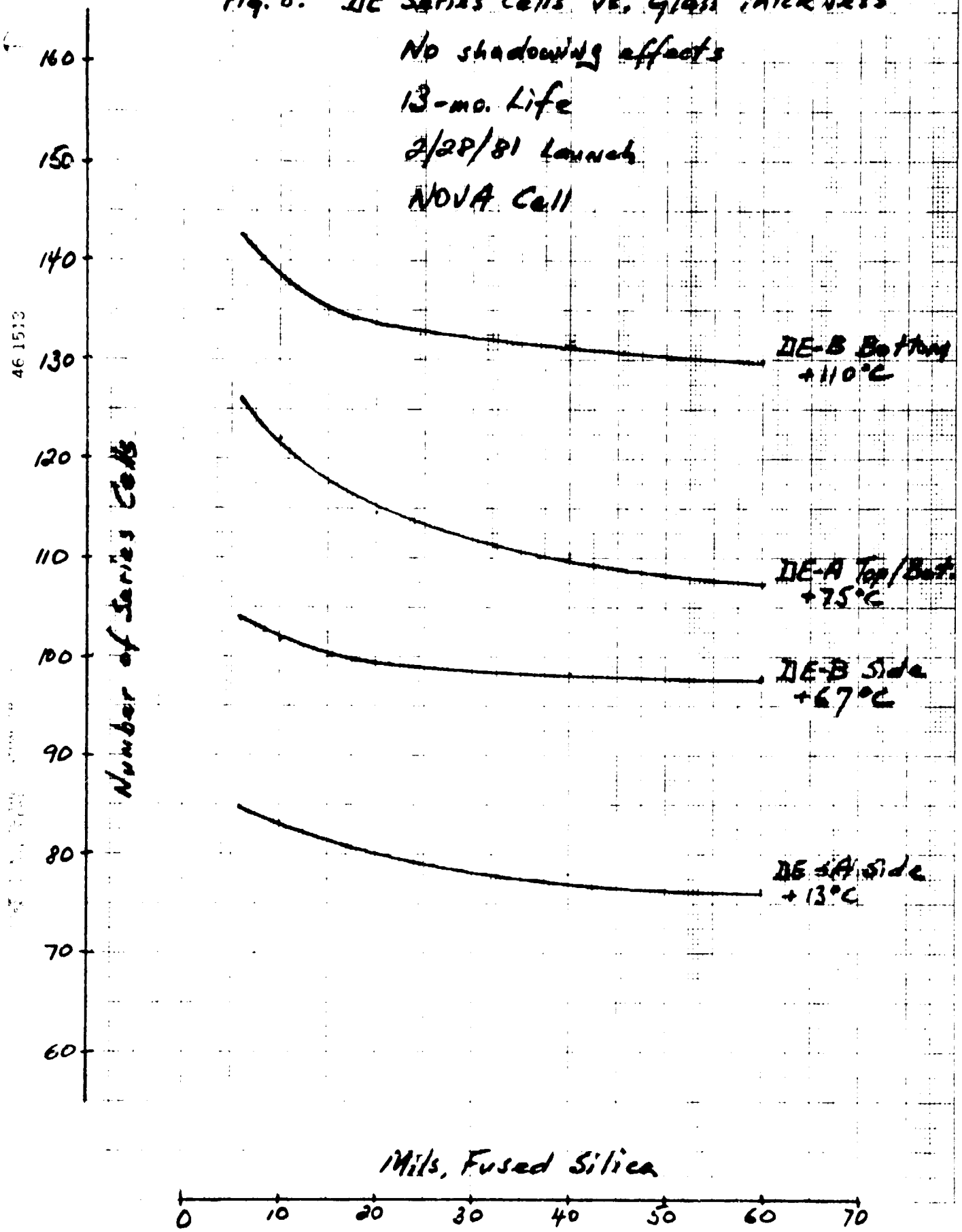
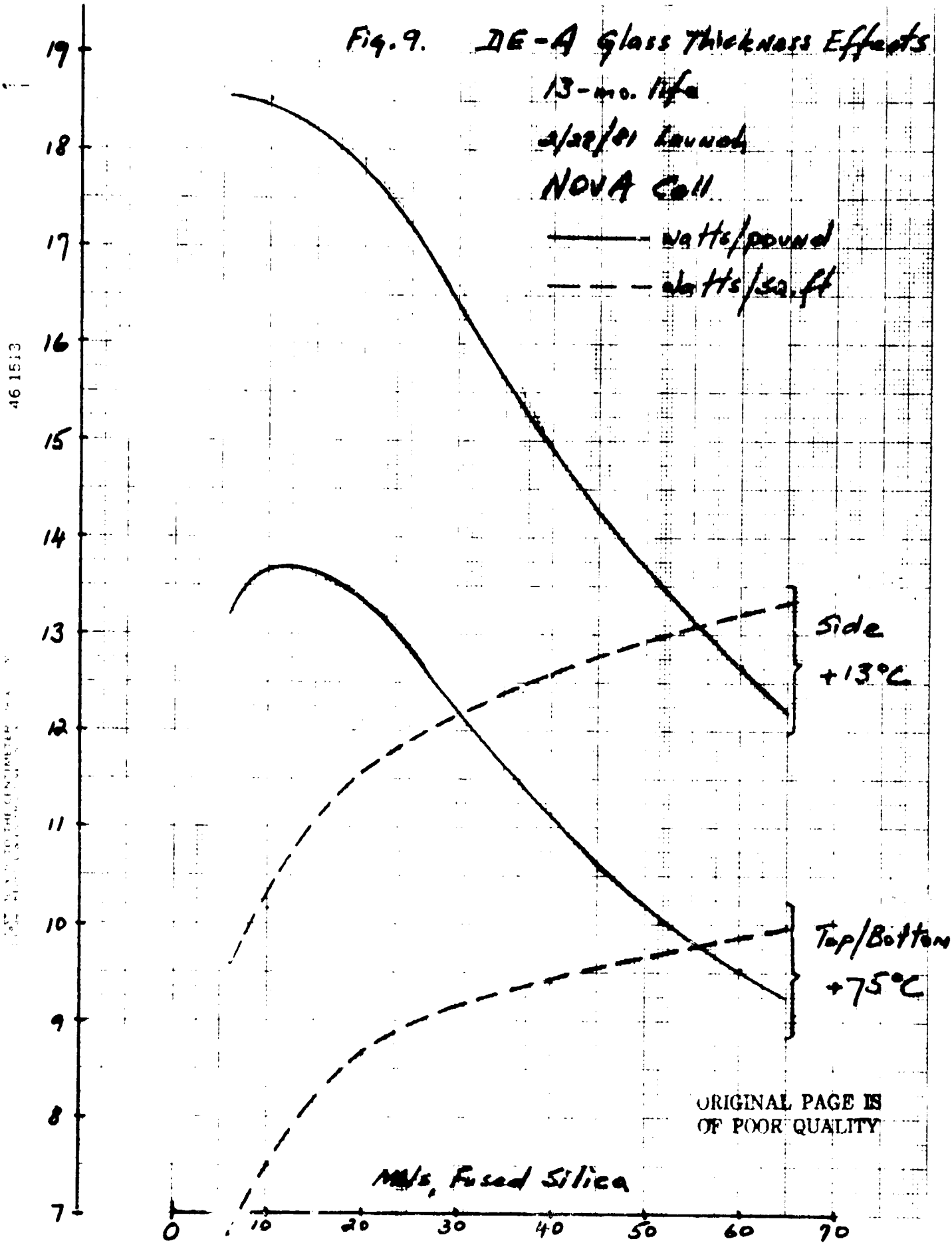
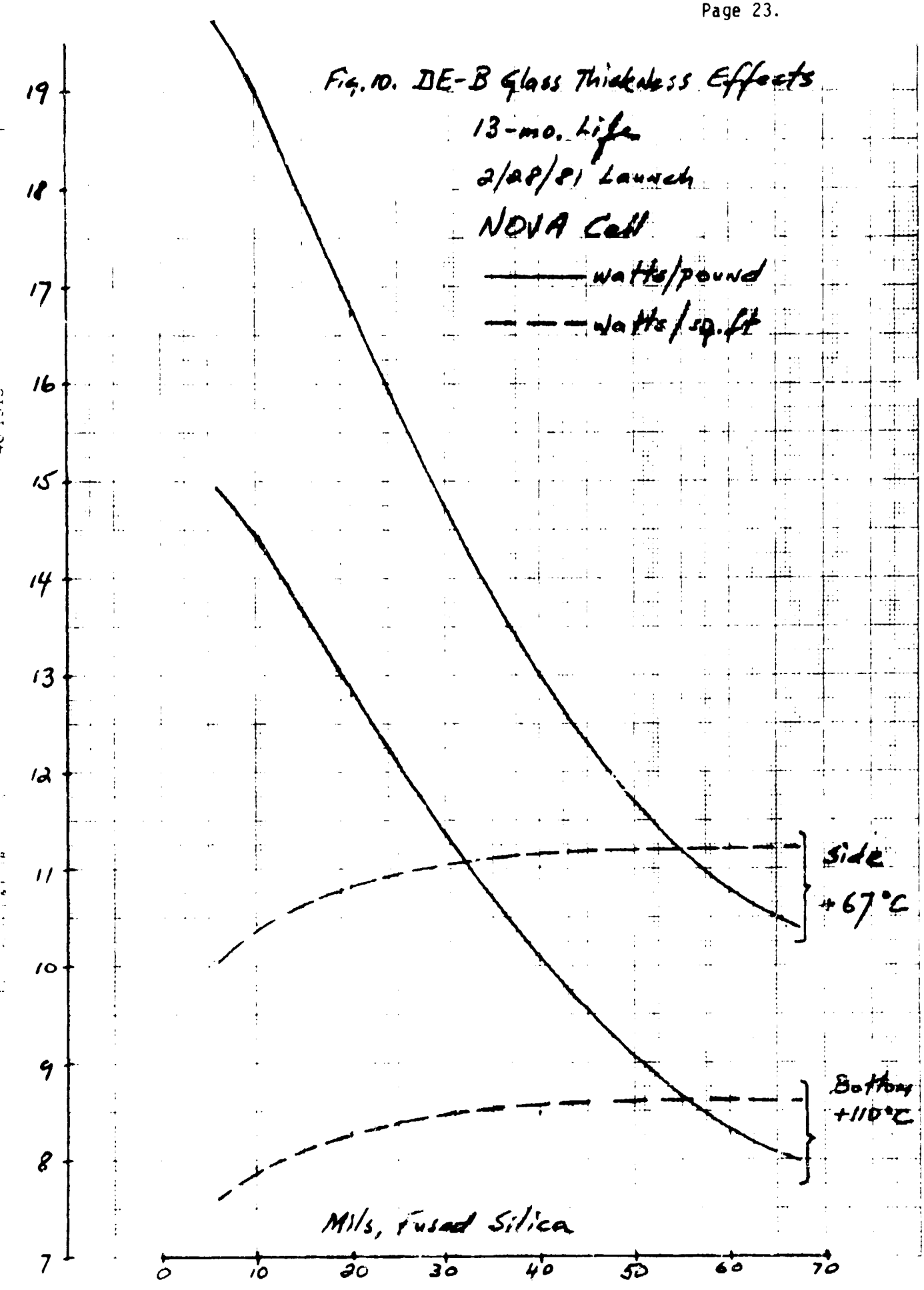


Fig. 9. DE-A Glass Thickness Effects



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Fig. 10. DE-B Glass Thickness Effects
13-mo. Life
2/28/81 Launch
NOVA Cell
watts/pound
watts/sq.ft
Side
+67°C
Bottom
+110°C
Mils, Fused Silica
19
18
17
16
15
14
13
12
11
10
9
8
7
0
10
20
30
40
50
60
70

5.3 Array Design Analysis

Ten different solutions are summarized in Table III. Duty cycle values tabulated in Column 5 for DE-A and DE-B have been computed under identical load profile conditions for each respective spacecraft as reported in the RCA Proposal, Reference (5).

The first two solutions are those of the DE solar arrays as proposed in Reference (5); the Proposal includes the details of the numerical analysis performed to arrive at the numbers tabulated.

Solutions 3 and 4 were obtained subsequent to the Proposal submission assuming a 12.5% power increase over the proposed solar cells and some adjustment in the number of series string quantities as given in Column 10.

Solutions 5 through 10 are based on the NOVA (OCLI) solar cell and, as such, are the primary object of the remainder of this discussion; the first four solutions are included in the table primarily for their historical significance and will not be discussed any further.

Rationale used in preparing Table III is discussed below.

Columns 1 and 2 identify the DE flight, A or B, and the solar cell data used in each solution.

Column 3 of Table III identifies the fused silica glass thickness applicable to each solution. Thirty and sixty mil thicknesses were considered: sixty, since our baseline designs to date were based on that thickness; thirty, since, relative to sixty, the EOL array power reduction in DE-B appears to be of the order of only one percent or less (Figure 10) while offering an overall weight reduction of approximately 26.8 pounds considering both DE spacecraft; Reference (6).

Column 4 identifies the Power Analysis Computer Program run number leading to the solution of the duty cycles given in Column 5. Computer runs for the 60 mil glass thickness solutions (No. 5 and 8) using the NOVA cell have not been made due to the small difference in the EOL side array power in DE-B as discussed in the preceding paragraph; specifically, in column 11, note that the increase is only 0.8 watts with 60 mils relative to the side power with 30 mils. The beginning-of-life (BOL) solutions (No. 7 and 10) have no practical significance other than to illustrate the increased amounts of array power available initially (Column 11). Note also that, given the BOL array power throughout lifetime (zero radiation damage), the 19% minimum duty cycle requirement in DE-B would be met. Computed Science On-Time Duty Cycle variation with life in orbit for solutions 6, 7, 9, and 10 is given in Figures 11-14.

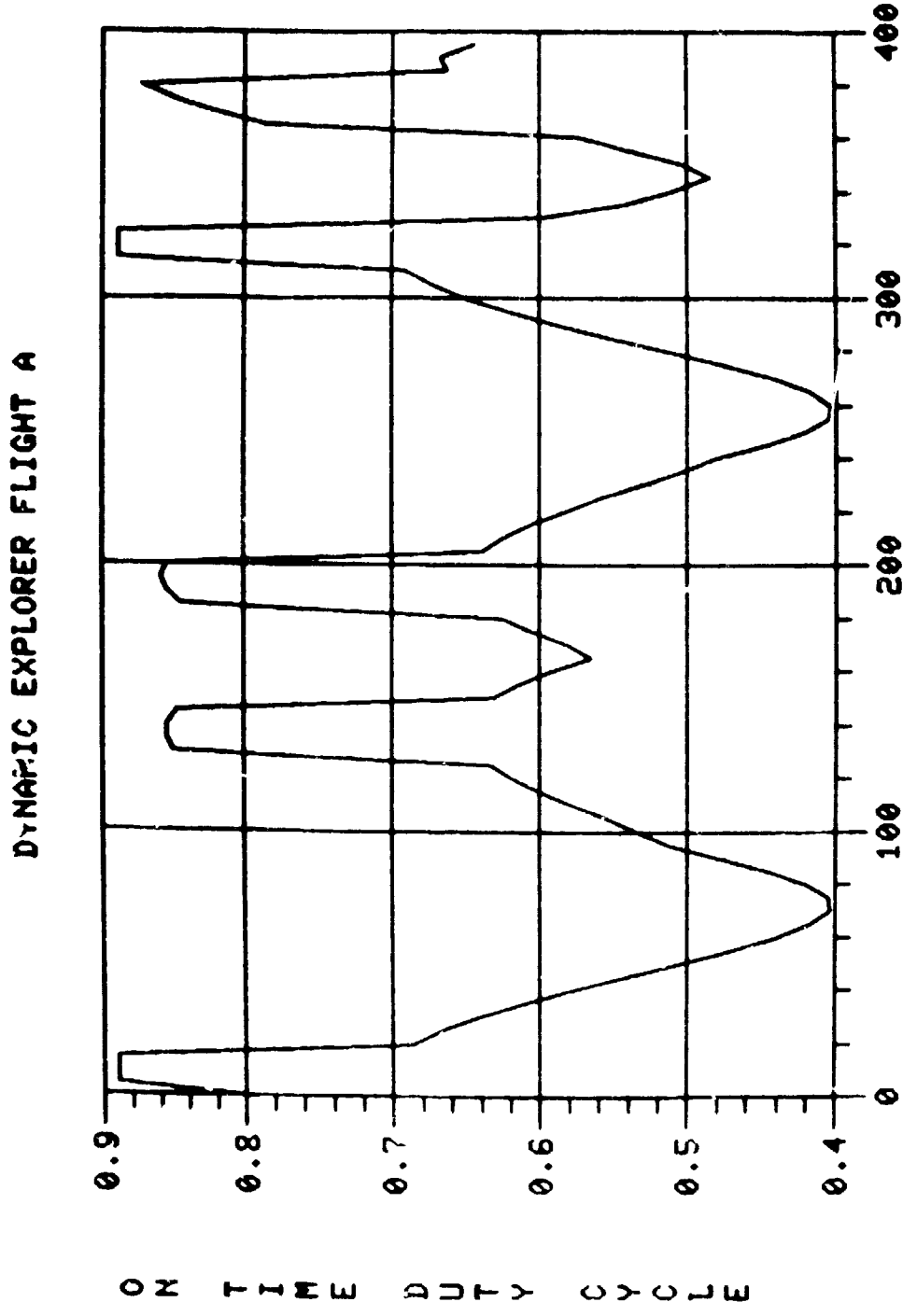


Fig. 11. DE-A Duty Cycle Variation, End-of-Life Array Throughout and 30-mil Coverglass
Reference: Table III, Solution 6

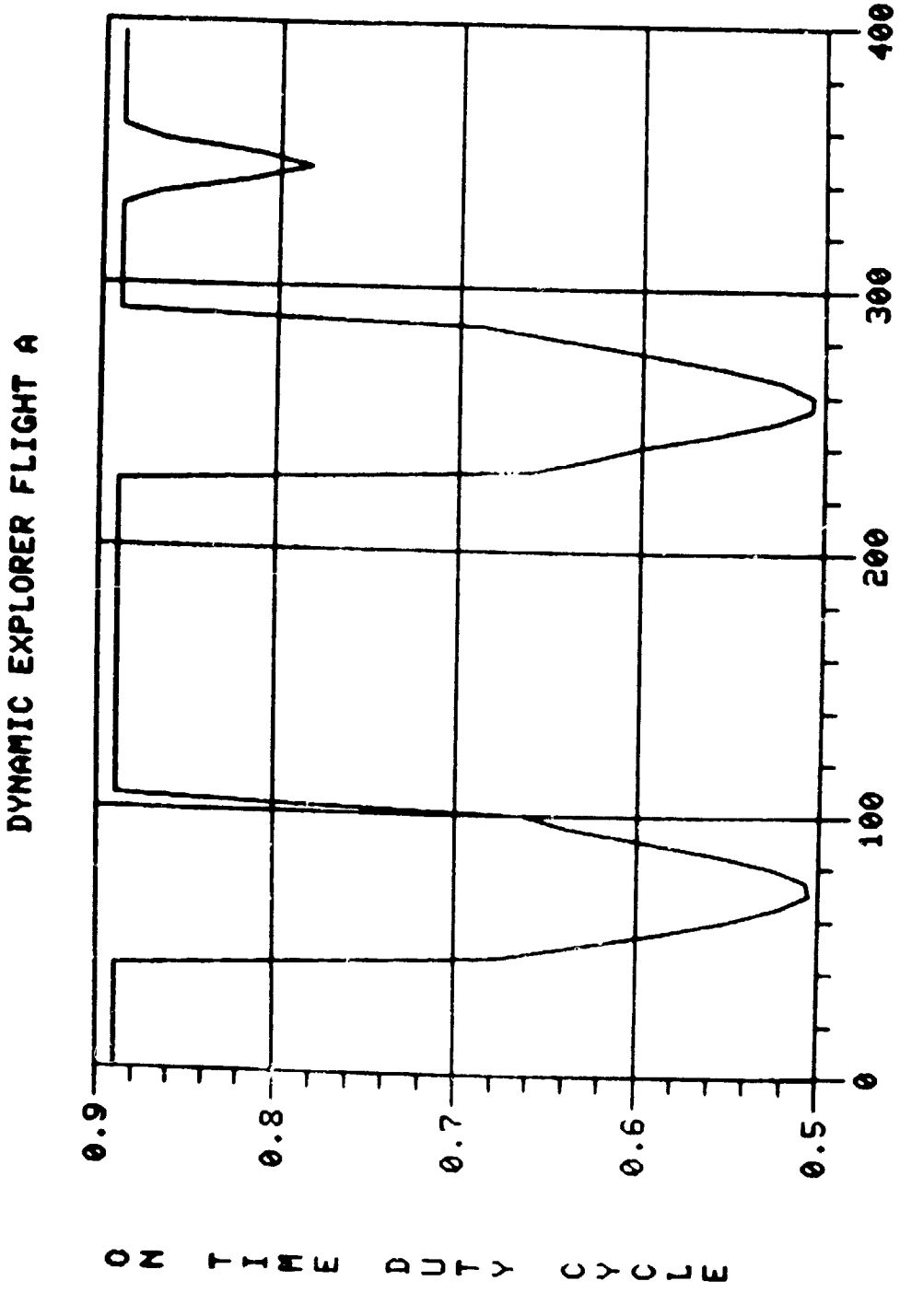


Fig. 12. DE-A Duty Cycle Variation, Beginning-of-Life Array Throughout
Reference: Table III, Solution 7

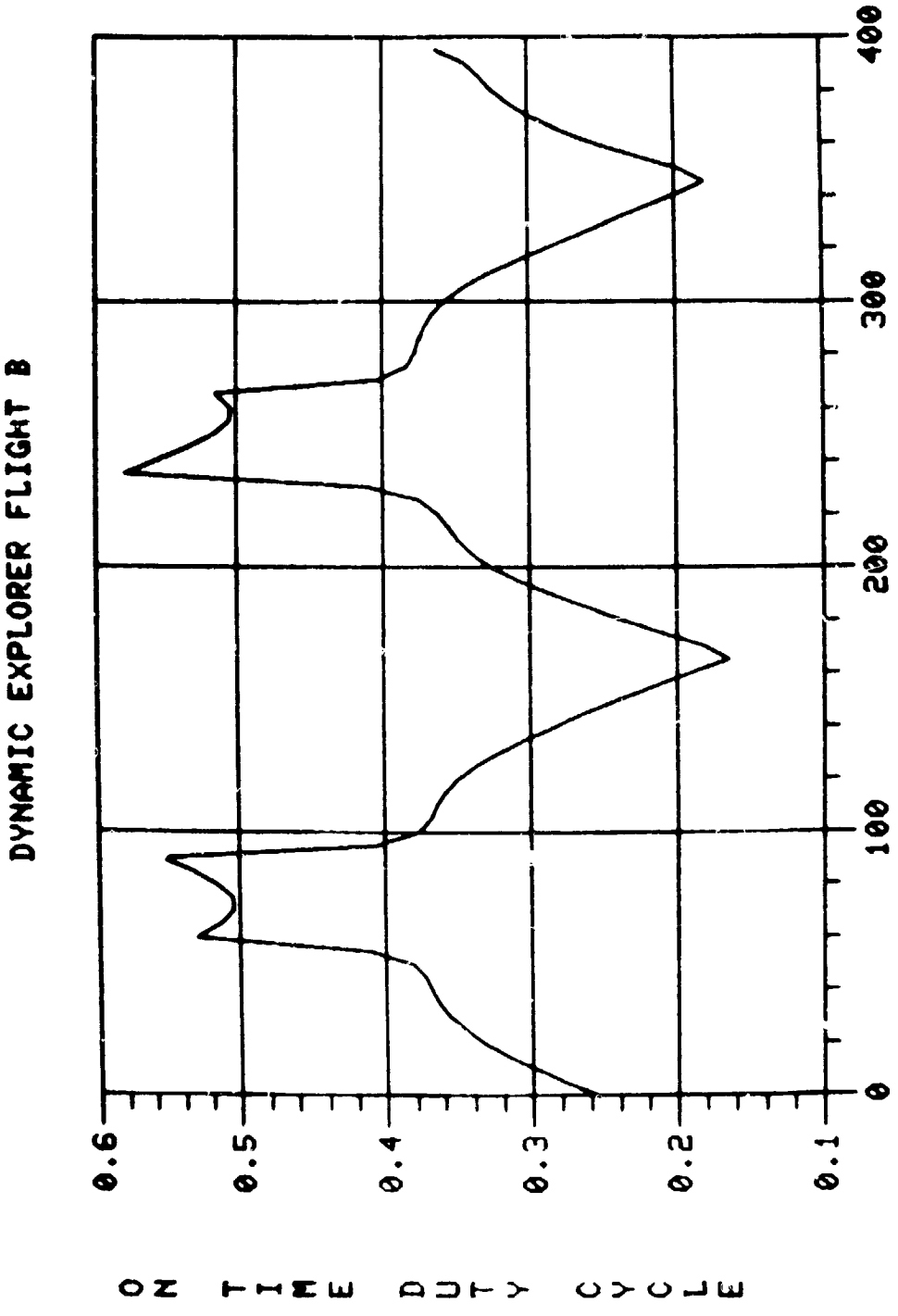


Figure 13. DE-B Duty Cycle Variation, End-of-Life Array Throughout and 30-mil Coverglass
Reference: Table III, Solution 9

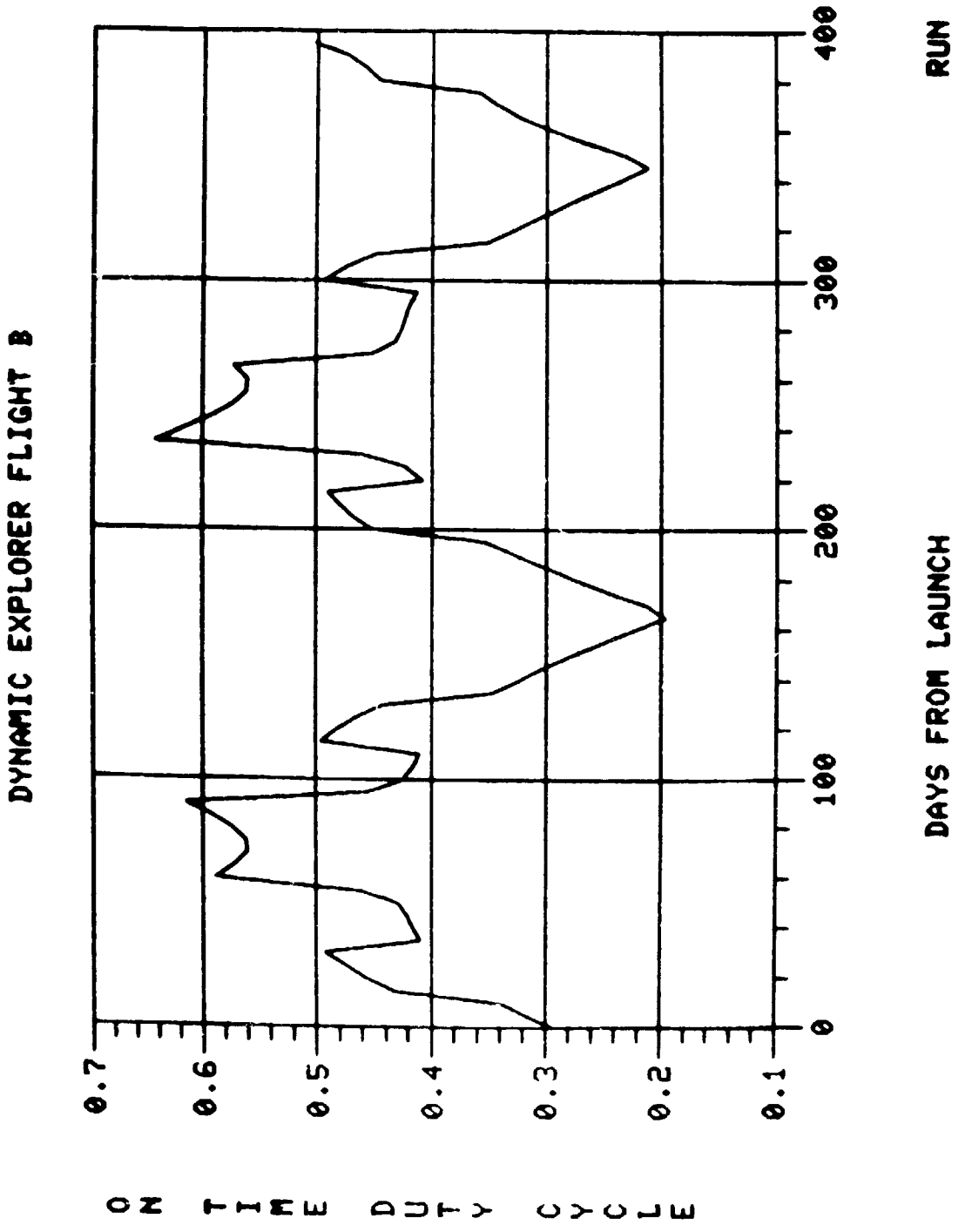


Figure 14. DE-B Duty Cycle Variation, Beginning-of-Life Array Throughout
Reference: Table III, Solution 10

Column 6 lists the total fluence in terms of the number of damage-equivalent 1-MeV electrons per sq. cm. for a thirteen-month life throughout (except where a BOL solution is identified) as applicable to solar cell current. (Reference (2).

Columns 7 and 8 identify the portion of the solar array and the maximum steady-state solar cell temperature currently predicted for that portion.

Column 9, the solar cell current in milliamperes per cell, is based on the broken-line curves in Figure 6, except that the BOL cell current of the NOVA cell solutions is computed as in this part 5.1.4.2, eq-N (4), but using:

d_{ri} = 1.0 (no radiation damage)

F_i = 1.0 (unirradiated cell)

d_i = 0.97 (UV damage only)

$i_{mp}(+25)$ = 151 ma as per Reference (1)

T = as in Column 8, this Table

Column 10 is self-explanatory. Column 11 is the maximum power at voltage V_s, Figure 3, computed for each portion of the array in each solution (sun vector normal to the spin axis for the side array, or normal to a flat-end array). In the NOVA cell solutions (No. 5 through 10), the computation is made as follows:

(a) From Sec. 5.1.4.1, eq-N(2), the voltage level V_s is 36.3 volts

(b) Assuming that the number of series cells is indeed 10% greater than that indicated in Figure 8 (refer to Part 5.4), then, in keeping with the assumption made in Part 3.2, there will be no loss of power due to shadowing. If so, the total maximum side array current is:

$$(\text{ma/cell, side, Column 9}) \cdot \frac{\text{No. of series strings, side, Col. 10}}{\pi}$$

For example, in solution 9, that would be

$$139.9 \cdot \frac{63}{\pi} = 2810 \text{ ma max. side array current}$$

		2	3	4	5		6	7	8	9	10	11
Solution No.	DE Flight	Origin of Cell Data	Mils Glass	Run No.	Duty Cycle Percent		1-MeV c/cm^2 Fluence (Current)	Array	Temp °C	Cell Current Ma/Cell	No.of Series Strings	Max. Power, Watts
					Min	Ave						
1	A	TIROS N	60	132	38	57.6		Side Ends	+13 +110	111.6 124.9	57 12	70.5 51.75
2	B	TIROS N	60	137	11	28.4		Side End	+67 +110	126 136	61 16	87.8 75.2
3	A	TIROS N + 12.5% Power	60	170	40	55.9		Side Ends	+13 +110		57 8	79.31 38.81
4	B	TIROS N +12.5% Power	60	180	16	35.3		Side End	+67 +110		63 16	101.73 85
5	A	NOVA, this DN	60	None			9.5×10^{13}	Side Ends	+13 +75	131.2 137.7	57 8	86.4 40
6	A	NOVA, this DN	30	183	40	62.3	2.7×10^{14}	Side Ends	+13 +75	124.2 132.2	57 8	81.8 38.39
7	A	NOVA, this DN		184	51	79.3	BOL	Side Ends	+13 +75	145.36 151.08	57 8	95.74 43.87
8	B	NOVA, this DN	60	None			2.2×10^{13}	Side End	+67 +110	141 145.1	63 16	102.64 84.27
9	B	NOVA, this DN	30	185	16	34.9	3.6×10^{13}	Side End	+67 +110	139.9 144.1	63 16	101.84 83.69
10	B	NOVA, this DN		186	20	41.5	BOL	Side End	+67 +110	150.35 154.31	63 16	109.45 89.62

TABLE III. SUMMARY OF ARRAY DESIGN SOLUTIONS

Similarly, the total maximum end array current would be:

(ma/cell, Column 9) (No. of series strings, end, Column 10)

Once again using solution 9 as an example, the bottom ("end") array current is

144.1 x 16 = 2310 ma maximum "end" current

(c) Therefore, the maximum power numbers tabulated in Column 11 for solution 9 are:

36.3 volts (2.81 amp.) = 101.84 watts, side

36.3 volts (2.31 amp.) = 83.69 watts, "end"

5.4 Series Cell Requirements and Protection Against Shadowing

Table IV summarizes the series cell requirements. Given the 2 x 2 cm cell size, it is seen that the series cells needed with the NOVA cell, including those additional series cells thought to be required to overcome the shadowing loss, are well within the numbers developed in Reference (8) using the TIROS N-vintage cell.

5.5 DE-B Side Array Preliminary Layout Considerations

For the present, we will limit the cell layout discussion to the DE-B side array as the most critical portion of the power-limited "B" array needed to provide an adequate Science On Time duty cycle. Discussion will be further limited to the 2 x 2 cm cell size, and only to those panels on the DE-B side array which have no cutouts which is assumed to be the case in the majority of those panels.

Given a "clean" side panel, up to 258 2 x 2 cm cells can be accommodated on such a panel allowing for six cells "lost" due to baseplate pickup holes.

From Table IV, it is seen that 99 cells in series are needed on the bottom hat portion of the DE-B side array where no shadowing is presumed to occur. A "clean" panel, therefore, can accommodate a single string of 99 two-cell modules plus one-half of an additional single-cell-module string:

$$2 \times 99 + 50 = 248 < 258 \text{ cells},$$

with the other half of the single-cell string mounted on an adjacent panel. Given a 17% cell current loss in the "split" string (Appendix to this DN), the power increase of the side panel in question as compared to a straight 2 x 99 - cell layout (no "split" string) would be

$$\frac{2 + 0.5\ (1-0.17)}{2} = 1.21, \text{ or } 21 \text{ percent}$$

On the side panels of the top "hat" where shadowing occurs, 109 series cells are required. With the 258-cell maximum limitation, the split-string approach is not possible,

$$2 \times 109 + 55 = 273 > 258 \text{ cells},$$

unless the string "size" is reduced from 109 to 103 cells:

$$2 \times 103 + 52 = 258 \text{ cells}$$

Such a reduction can be implemented if the temperature of the DE-B side cells on the top "hat" can be reduced from +67 to +58°C maximum (as determined by proper reference to Figure 4), in which case a 21% power gain can also be obtained from the top hat portion of this side array.

TABLE IV. DE SERIES CELL REQUIREMENTS

DE Flight	Number of Series Cells						Remarks
	Side Array			Flat-End Array			
	Need			Need			
	If No Shadows (1)	10% (2)	(3)	If No Shadows (1)	+10% (2)	(3)	
A	78	86	86	112	123	156	
B	99	(4)	121	132	145	156	Bottom "Hat"
B	99	109	121	-	-	-	Top "Hat"

NOTES:
(1) Figure 8, with 30-mil glass.
(2) To get rid of all shadowing loss, Part 3.2.
(3) References (5) and (8), 2 x 2 cm cells (series cells proposed, TIROS N cell data).
(4) "+10%" not required; Part 3.3.

6.0 REFERENCES

1. NOVA Solar Cell Specification, RCA 2285464, Dash One, Rev. Ltr. E.

2. Figure 5, DE Radiation Environment Analysis, G. Brucker/ R. Ohanian, Rev. A, DE File 2.4.4-003-DN.

3. Letter, Dieter K. Zemmrich (OCLI) to R. Devaux, RCA, June 21, 1978, with enclosures:

   (a) Quality Assurance Engineering Report 010, June 14, 1978, OCLI High-Efficiency Solar Cell. (Includes temperature coefficient and NRL electron irradiation data).

   (b) Irradiation data, dated March 31, 1978, performed at Hughes A/C with OCLI Solar Simulator, as implied in referenced letter. OCLI High Efficiency Cells with fluences corrected for bare-cell exposure.

4. Solar Cell Radiation Handbook, JPL Publication 77-56, November 1, 1977.

5. RCA Proposal No. 102658-C, June 30, 1978, Dynamics Explorer (DE)-A and -B Spacecraft, Part 2, Book 1, Section 3.2.

6. R. G. Horner, Preliminary Tradeoff of 60 mil vs. 30 mil Solar Cell Covers, September 5, 1978, DE File 3.4.7.2-006.

7. DE Power Analysis Computer Programs, DE File Numbers 2.4.2-005 and 2.4.2-007-DN.

8. W. Fuldner, Considerations Affecting the Implementation of Solar Cell Bypass Diodes and Resulting Solar Array Output Noise, May 15, 1978, DE File 2.3.3-023-DN.

APPENDIX

Amount of Power Lost if Elements of a String of Series-Connected Solar Cells Are Placed on Adjacent Panels of a n-Sided Configuration.

APPENDIX

Major assumption is that the instantaneous magnitude of the string current of a "split" string is limited to the magnitude of the maximum-power-point current generated by the cell which is subject to the lowest solar incidence angle (furthest off normal incidence). Thus, with the sun vector location as shown in the attached sketch, the current of the series string split between the adjacent sides "a" and "b" (the dotted line) would equal essentially that of the cells on side "b". An added assumption is that the maximum-power-point current of an off-normally illuminated solar cell obeys the cosine law.

Referring to the attached sketches, let the sun vector be placed along the -90° position in the sketch at the top of the page, and let the spacecraft be rotated clockwise as shown. Over each 2π rotation of the angle α, each independent string located on sides "a" and "b" would generate instantaneous power proportional to the cosinusoids shown at the bottom of the page. The split string, however, would produce power proporational to the shaded area, that is, area shared by both cosinusoids. Fraction of power generated by a split string as compared to a normal string (whose cells are all in one plane) is therefore given by

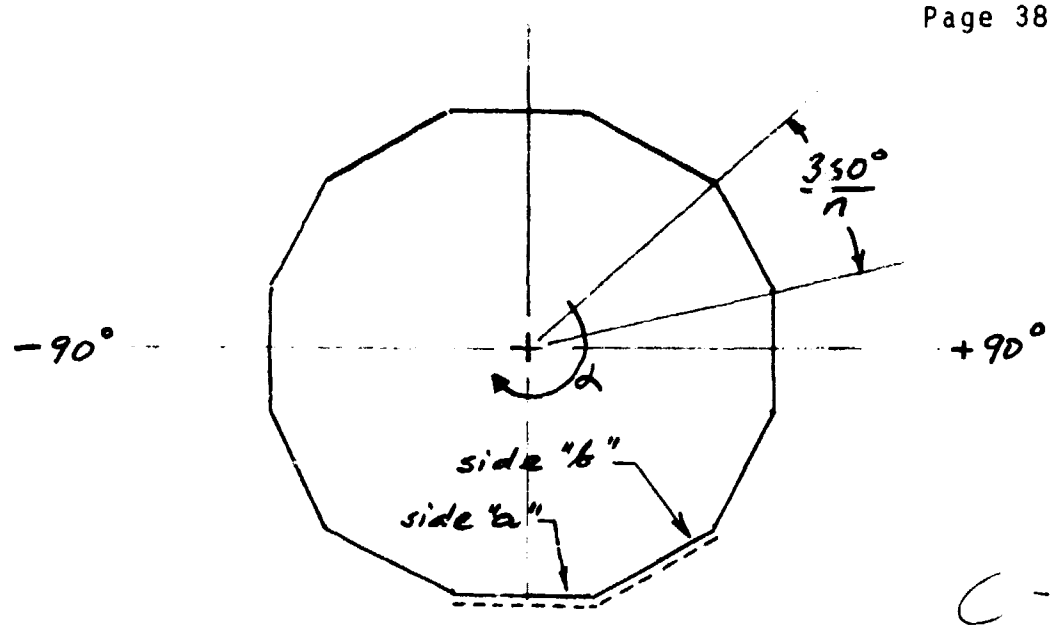
$$\text{Fraction} = \frac{\int_{-90+\frac{360}{n}}^{\frac{360}{2n}} \cos\left(\alpha - \frac{360}{n}\right) d\alpha + \int_{\frac{360}{2n}}^{+90} \cos\alpha \, d\alpha}{\int_{-90}^{+90} \cos\alpha \, d\alpha}$$

$$= 1 - \sin\frac{180^\circ}{n}$$

or, for a 18-sided configuration such as DE (n = 18),

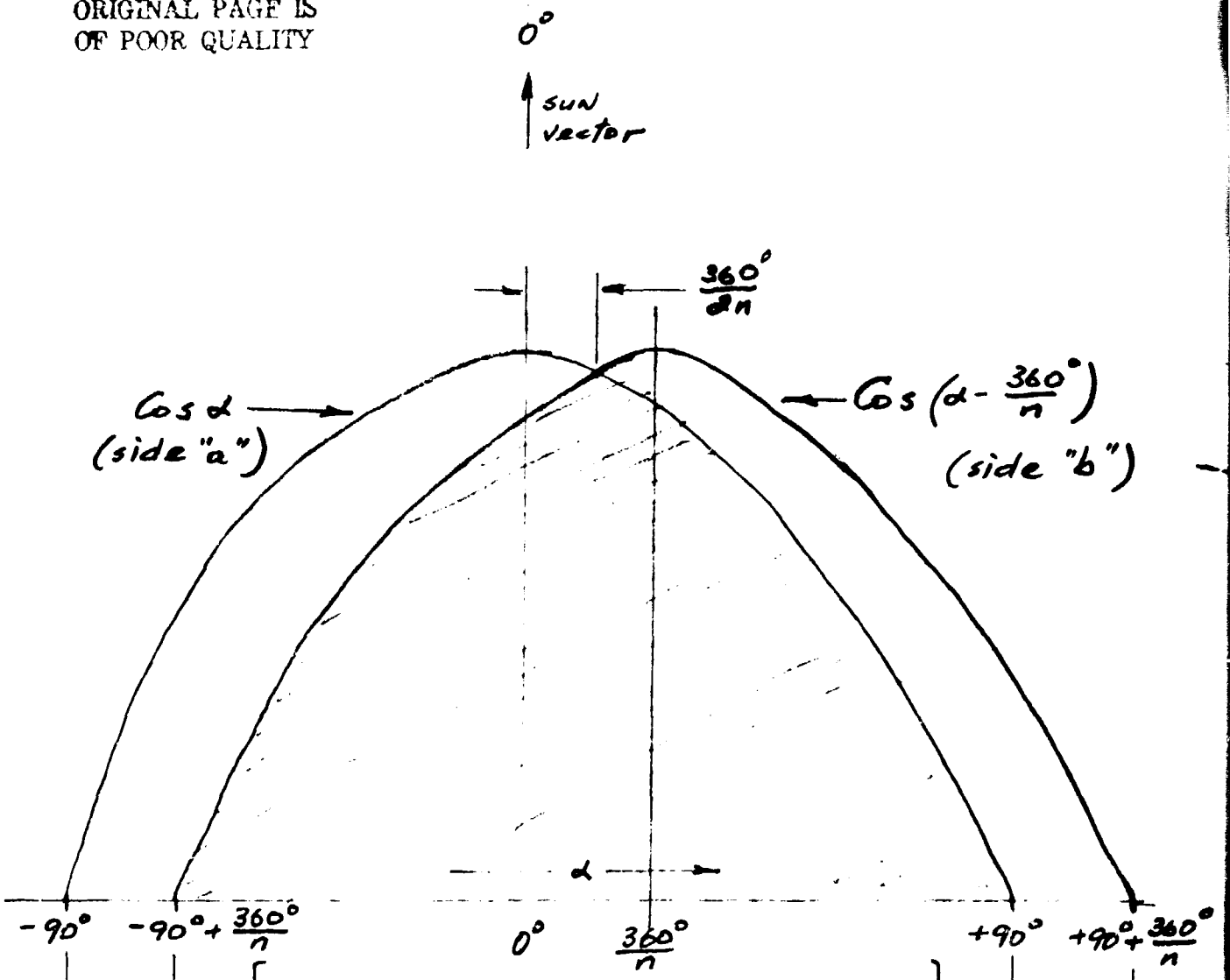
Fraction = 0.8264,

which represents about a 17% loss in a "split" string relative to a "normal" one.



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DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No. 3.4.2-006-DN
Title: SHADOWING OF SOLAR CELLS	
Written by: PAUL NEKRASOV	Date: 12 October 1978
Approved by: W. V. Fuldner	Date: 13 October 1978
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

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Letter	Description	Date	Author

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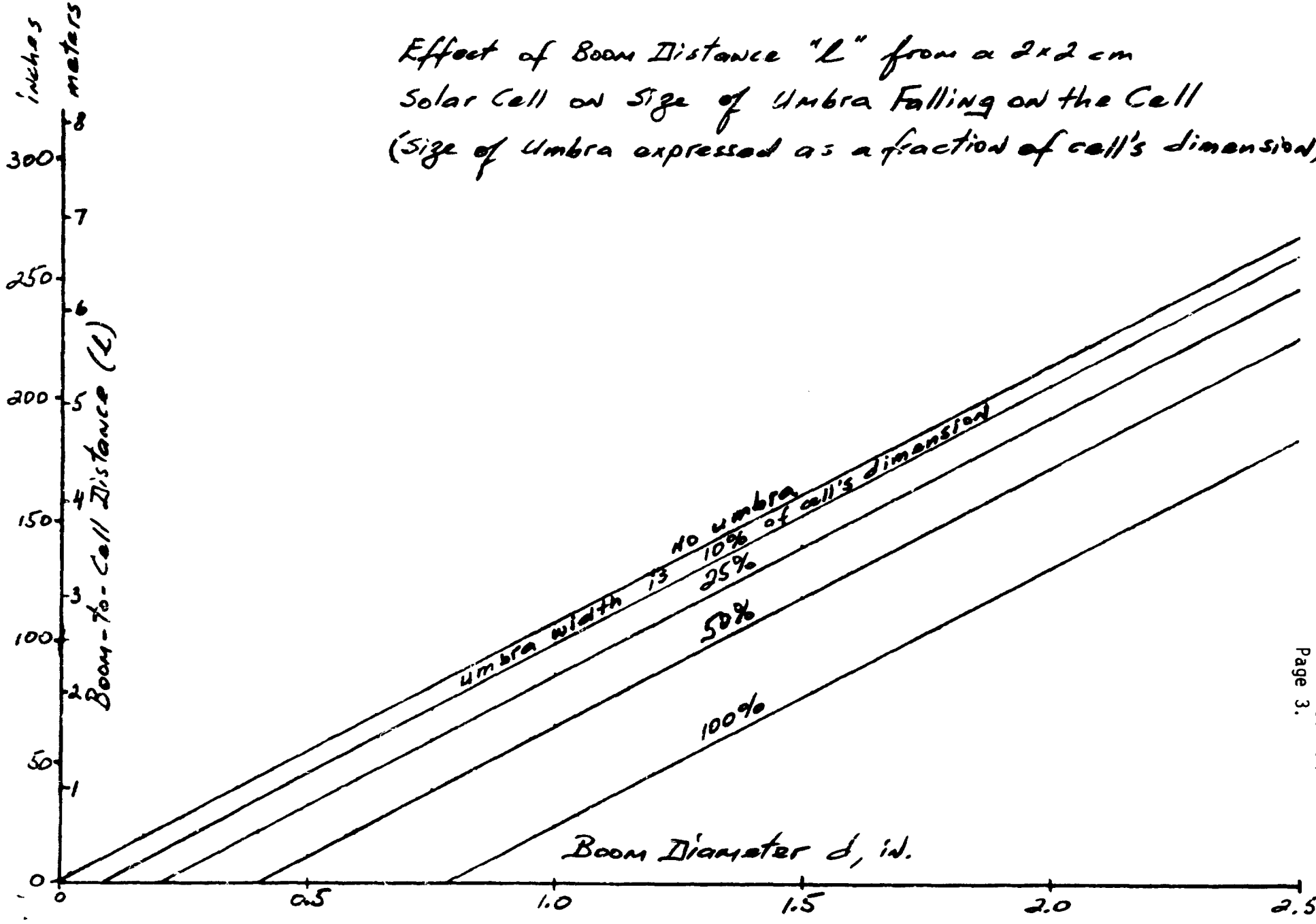
The shadowing analysis reported in this note has been performed as a possible aid in the on-going solar cell layout effort on DE Spacecraft. In particular, a significant portion of the layout work will consist of identifying those selected locations on the solar arrays where the bypass diodes are required to protect against shadowing losses.

Shadowing loss is most severe in the umbra region, that is, where complete shadow of an opaque body such as a boom results in a complete cutoff of light. In the partial shadow region of penumbra where the source of light is only partially cut off, the loss of solar cell power is not as severe. Given an opaque body of a fixed size, its distance from the cells is the critical parameter which determines the umbra configuration.

Results are provided in the attached plot. It is seen, for instance, that the 0.166-inch-dia. tip of the 22-inch long LANG boom will not produce an umbra in DE-B (the 0.182-inch-dia. base of the boom, however, will cast a complete shadow of up to approximately 10 to 20% of a 2x2 cm solar cell's area). Similarly, the attached plot shows that any opaque elements mounted on the stub boom at the end of the 5.9-meter long Astromast will not produce an umbra in DE-A unless the dimensions of the opaque parts exceed about two inches.

Details of the supporting analysis follow.

Effect of Boom Distance "L" from a 2×2 cm Solar Cell on Size of Umbra Falling on the Cell
(Size of Umbra expressed as a fraction of cell's dimension)



Supporting Analysis

SYMBOLS:

L	distance to which umbra extends
ℓ	distance from opaque object to solar cell
S	solar cell dimension, e.g., 2 cm as in 2 x 2 cm cell
p	fraction of solar cell dimension "S" covered by umbra
d	dimension of opaque body, e.g., boom diameter
α	angle subtended by solar disc (0.5331° at mean distance to sun)

By reference to the attached sketch, basic relationships (1) and (2) are written. Substituting for "α" into (1) and solving for "L",

$$L = 107.47583\ d \qquad (3)$$

From eq-n (2),

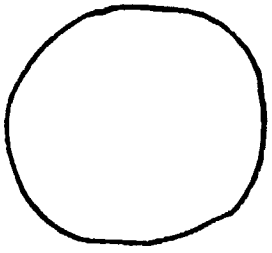
$$\ell = L\left(1 - \frac{sp}{d}\right) \qquad (4)$$

Substituting for "S" of a 2 x 2 cm cell and for "L" from eq-n (3) into eq-n(4),

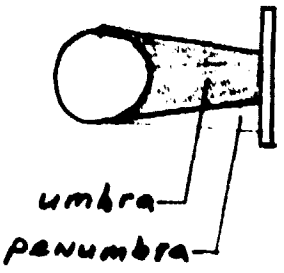
$$\ell = 107.47583\left(d - \frac{P}{1.27}\right) \text{ inches} \qquad (5)$$

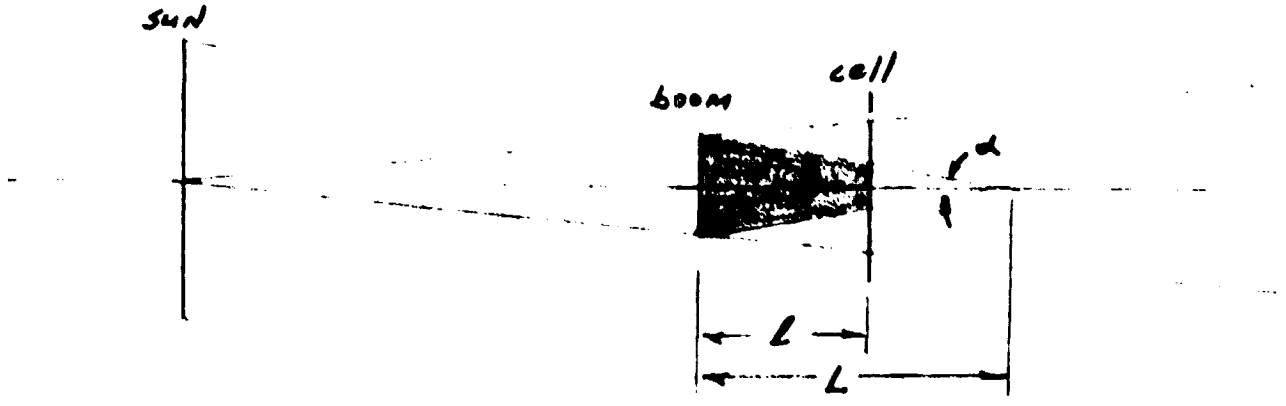
Equation (5) is plotted in the attached figure for p=0 (no umbra), 0.1, 0.25, 0.5, and 1.0.

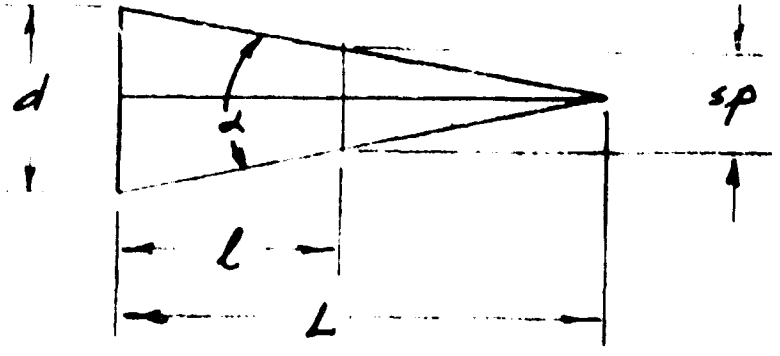
solar disc



boom, dia. "d" solar cell, dimension "s"







$$\frac{d}{2L} = \tan\frac{\alpha}{2} \qquad (1)$$

$$\frac{d}{sp} = \frac{L}{L-l} \qquad (2)$$

6.0 COMMUNICATIONS SUBSYSTEM DESIGN NOTES

TABLE OF CONTENTS

Design Note	Title
3.5.2-004-DN	Antenna Test Plan
3.5.2-005-DN	Antenna Coverage During DE-A Spin-Precession Maneuver

DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No.
Dynamics Explorer	3.5.2-004-DN

Title

Antenna Test Plan

Written by: D. McGiffney	Date
Approved by: D. Shipley	Date 25 Sept 78
This DN supplements (S), replaces (R) DN Nos. ( ) ( )	

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Letter	Description	Date	Author

Distribution:
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D. Shipley

Testing of the brass-board and protoflight models of the three DE antennas will be as described below. The attached table summarizes the sequence of tests.

I. Brass-board Model Tests

Brass-board models of each of the DE antennas will undergo bench tests and pattern measurements at the AE antenna range. After these tests, the brass-board antennas will be shipped to GSFC where they will be mounted on an RF mock-up of the DE spacecraft. The mock-up will be able to simulate both DE-A and DE-B. Pattern measurements will be made to determine the effect of the spacecraft body and appendages on antenna performance. After the mock-up tests the brass-board antennas can be returned to AE if needed.

II. Protoflight Tests

The protoflight antennas will undergo bench tests and pattern measurements at the AE antenna range. These tests will verify that the protoflight antennas are within specification and that there is good correspondence between the protoflight and brass-board performance. Afterwards, the protoflight units will be shipped to GSFC for tests with the RF mock-up. The protoflight antennas then will be returned to AE for the remainder of the component level test cycle. Also, the RF mock-up will be sent to AE for use in calibrating the integration area antenna range.

At AE the protoflight units will undergo thermal tests to verify VSWR performance over temperature, and then will be subjected to vibration. Afterwards, the antennas will undergo bench tests and abbreviated pattern measurements to verify that their performance has not been altered by the environmental exposure. The final component level test will be an RF breakdown test, which will check for ionization breakdown at critical pressure and multipactor breakdown in hard vacuum.

After the component level tests, the protoflight antennas will be integrated onto their respective spacecraft and tested at the integration area antenna range. These tests will consist of EIRP measurements (transmitters ON) at a few selected angular coordinates, and partial patterns of the high gain antenna beam. The purpose of these tests is to provide a data reference for the post-environmental spacecraft level tests and to establish the validity of the RF mock-up tests. After this pre-environmental test, the spacecraft will be subjected to the required environmental exposures, and the pre-environmental tests will be repeated to verify that the exposures did not alter spacecraft performance. After the post-environmental test, each antenna will be removed from its spacecraft and undergo a bench test to verify that its VSWR is still within specification.

When the antennas are re-integrated onto the spacecraft, a go/no-go check of EIRP will be performed using a near-field coupler ("sniffer") or equivalent. This test will verify that the antenna has been correctly installed and is still functioning properly.

DE ANTENNA TEST PLAN

SPECIFICATION REQUIREMENT	PARA. NO.	BRASS-BOARD			PROTO-FLIGHT (AT AE UNLESS OTHERWISE NOTED)												
					BEFORE INTEGRATION								INTEGRATED ON S/C			REMOVED FROM S/C	RE-INSTALLED ON S/C
		AT AE		AT GSFC ON RF MOCK-UP			AT GSFC ON RF MOCK-UP										
		BENCH TEST	PATTERN MEAS.	PATTERN MEAS.	BENCH TEST	PATTERN MEAS.	PATTERN MEAS.	THERMAL TEST	VIBRATION(1)	POST ENV. BENCH TEST	ABBREV. PATTERN MEAS.	RF BREAK-DOWN TEST(2)	ANTENNA RANGE TEST PRE-ENV. (3)	S/C ENV. TESTS	ANTENNA RANGE TEST POST ENV. (3)	POST-ENV. BENCH TEST	GO/NO GO TEST (4)
INPUT VSWR	3.1.7.1	M,L,H			M,L,H			M,L,H		M,L,H		M,L,H				M,L,H	
GAIN	3.1.1.1		M,L,H	M,L,H		M,L,H	M,L,H				M,L,H						
AXIAL RATIO	3.1.1.1.2		L,H	L,H		L,H	L,H				L,H						
RF POWER HANDLING	3.1.1.1.5											M,L,H					
EIPP	—												M,L,H		M,L,H		M,L,H

M = DE-A MEDIUM GAIN ANTENNA

L = DE-B LOW GAIN ANTENNA

H = DE-B HIGH GAIN ANTENNA

(1) TESTED ON FIXTURE WHICH SIMULATES SPACECRAFT MOUNT.

(2) TESTED IN 10" BELL JAR AT 25°C, CRITICAL PRESSURE AND 10^{-5} TORR.

(3) PARTIAL PATTERNS AND SELECTED POINTS MEASURED TO VERIFY VALIDITY OF RF MOCK-UP TESTS AND TO VERIFY THAT ENV. TESTS DID NOT CHANGE PATTERNS.

(4) TESTED WITH NEAR FIELD ANTENNA COUPLER OR EQUIVALENT.

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DYNAMICS EXPLORER

Design Note

RCA Astro Electronics

Originating Project or Group	Note No.
Dynamic Explorer	3.5.2-005-DN

Title

Antenna Coverage During DE-A Spin Precession Maneuver

Written by	D. McGiffney	Date	28 Sept 78
Approved by	W. Fuldner	Date	28 Sept 78
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( )	( )		

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Letter	Description	Date	Author

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W. Fuldner
G. Hogan
W. Hord
C. Hume
D. McGiffney
H. Rickert
D. Shipley

The DE-A spacecraft will be injected into its final orbit while spinning at 70 rpm with its spin axis lying in the orbital plane. The spin axis then will be precessed until it reaches the desired orientation, i.e., normal to the orbital plane. Afterwards the spin rate will be decreased and the medium gain antenna will be deployed. Before deployment the antenna will not be able to provide reliable coverage and therefore some other means must be found to provide ground station contact when the antenna is in the stowed position.

A possible solution to the problem would consist of mounting two antennas with hemispheric coverage patterns on opposite ends of the spacecraft, as shown in Figure 1. The antennas would be circularly polarized, with opposite sense. A power splitter and RF switch are also required. After the final spin axis orientation is attained and the medium gain antenna is erected, the switch position would be reversed. The presence of a switch between the antenna and the command receiver raises a serious reliability question, since a switch failure could result in the inability to command the spacecraft. However, this point will not be discussed further, other than to point out that the switch would need to be operated only once during the mission.

The antennas would be of quadrifilar construction with a pattern as shown in Figure 2, based on measured data. While operating with these antennas it would be necessary for the ground station to switch its polarization sense twice each orbit, i.e., when the X-Y plane of the satellite passes through the ground station.

Taking into account blockage and reflection due to the top and bottom surfaces of the spacecraft, undesired coupling from the opposite sense antenna, and assuming a 26-meter ground station, the resulting antenna performance would be adequate for commanding and ranging throughout the orbit. The HEW data channel, however, could not be supported over the entire orbit. Figure 3 shows the portion of the orbit during which adequate HEW margin would be obtained with the ranging channel off. Between 31% and 72% of the orbit period would be serviceable, depending on the precession angle. Note that the link performance would be better at the beginning of the precession maneuver than at the end.

Figure 3 was derived assuming that the HEW channel modulation index is 0.3 radian per the current baseline. However the index could be changed to 1.4 radians by command (this index is normally used with the real-time data channel). The higher index would provide adequate HEW margin throughout the entire orbit, for any precession angle. During ranging, however, it would be necessary either to turn off the HEW modulation or switch back to the low index.

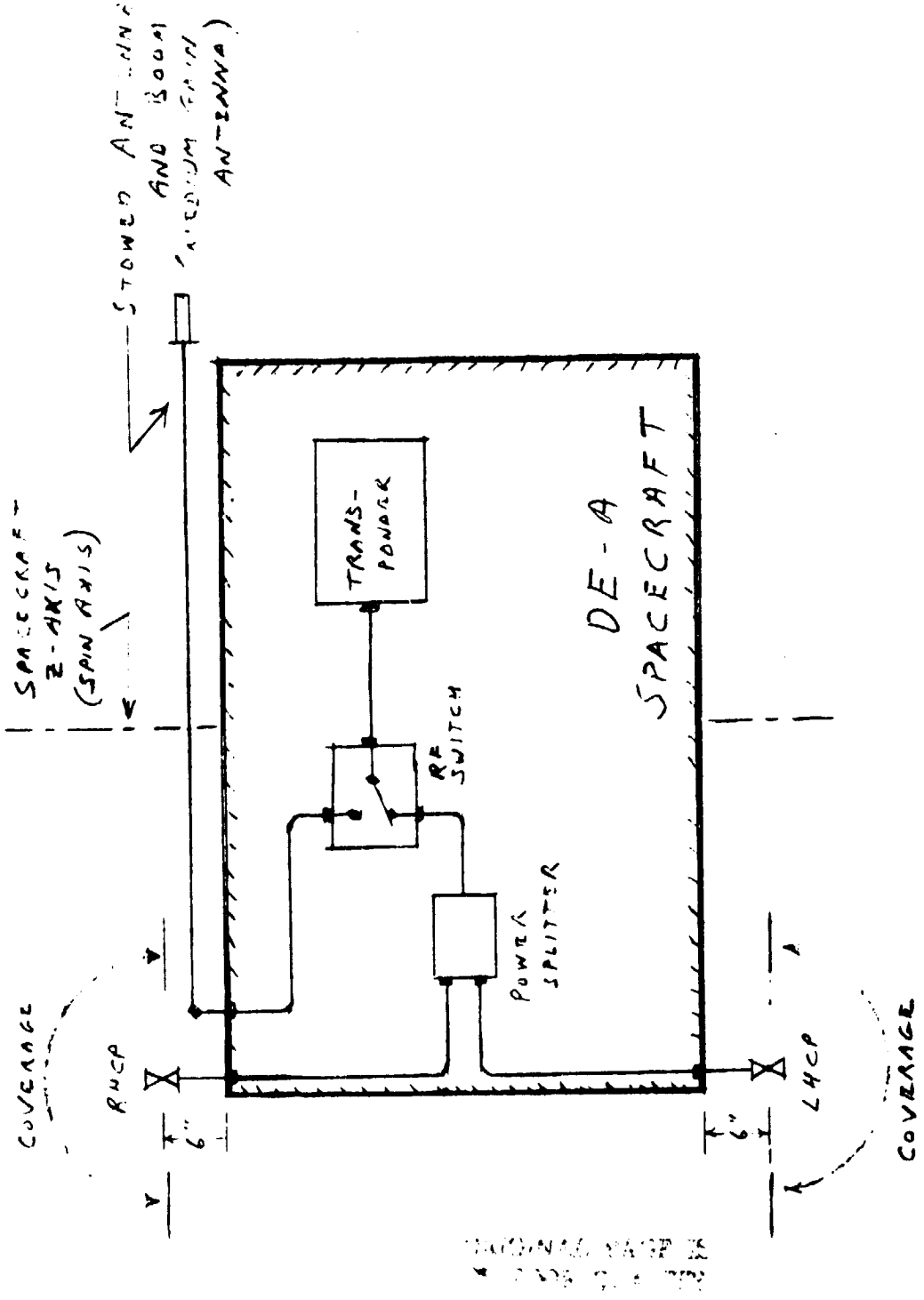
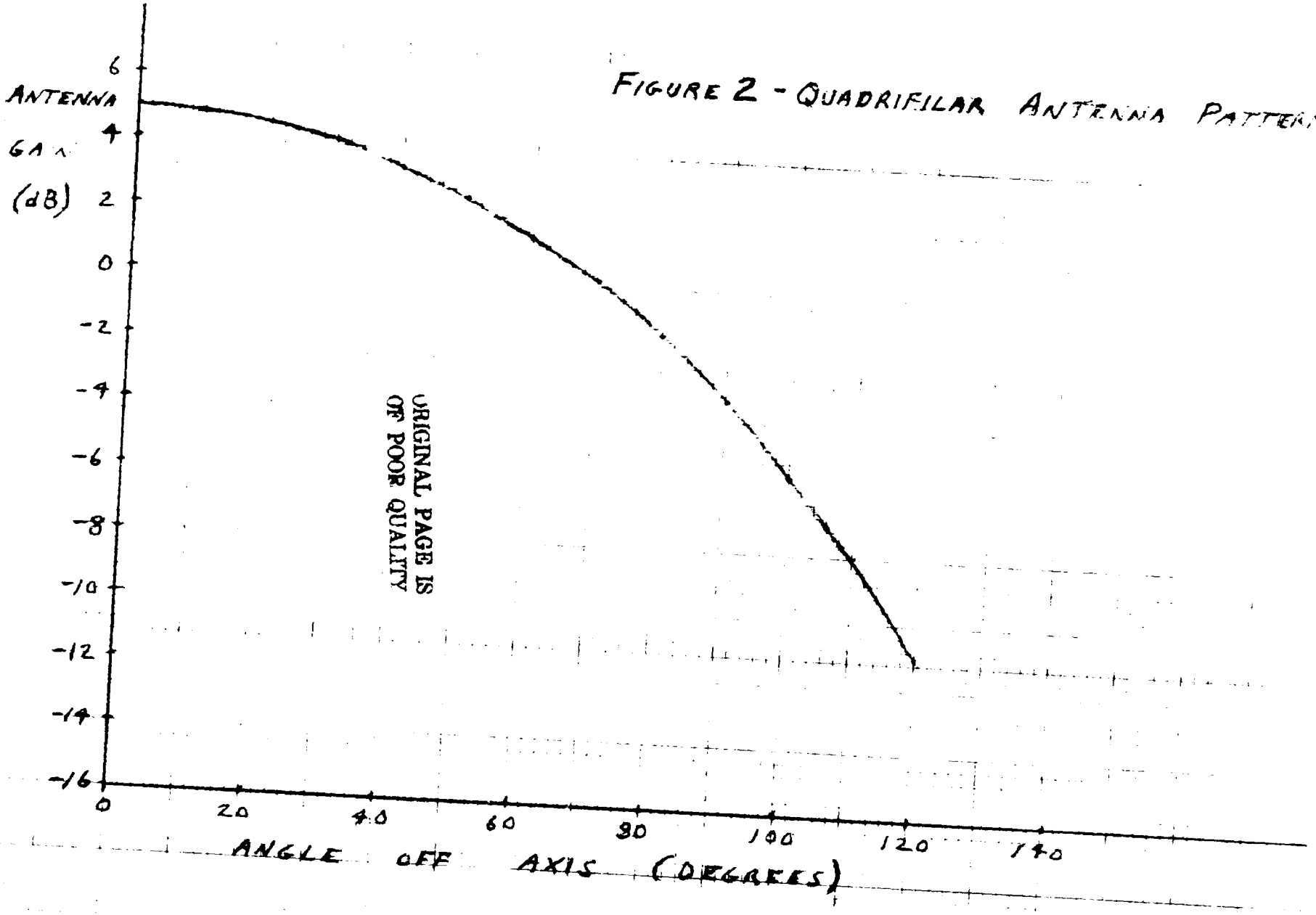


FIGURE 1 - DE-A WITH HEMISPHERIC COVERAGE ANTENNAS

FIGURE 2 - QUADRIFILAR ANTENNA PATTERN



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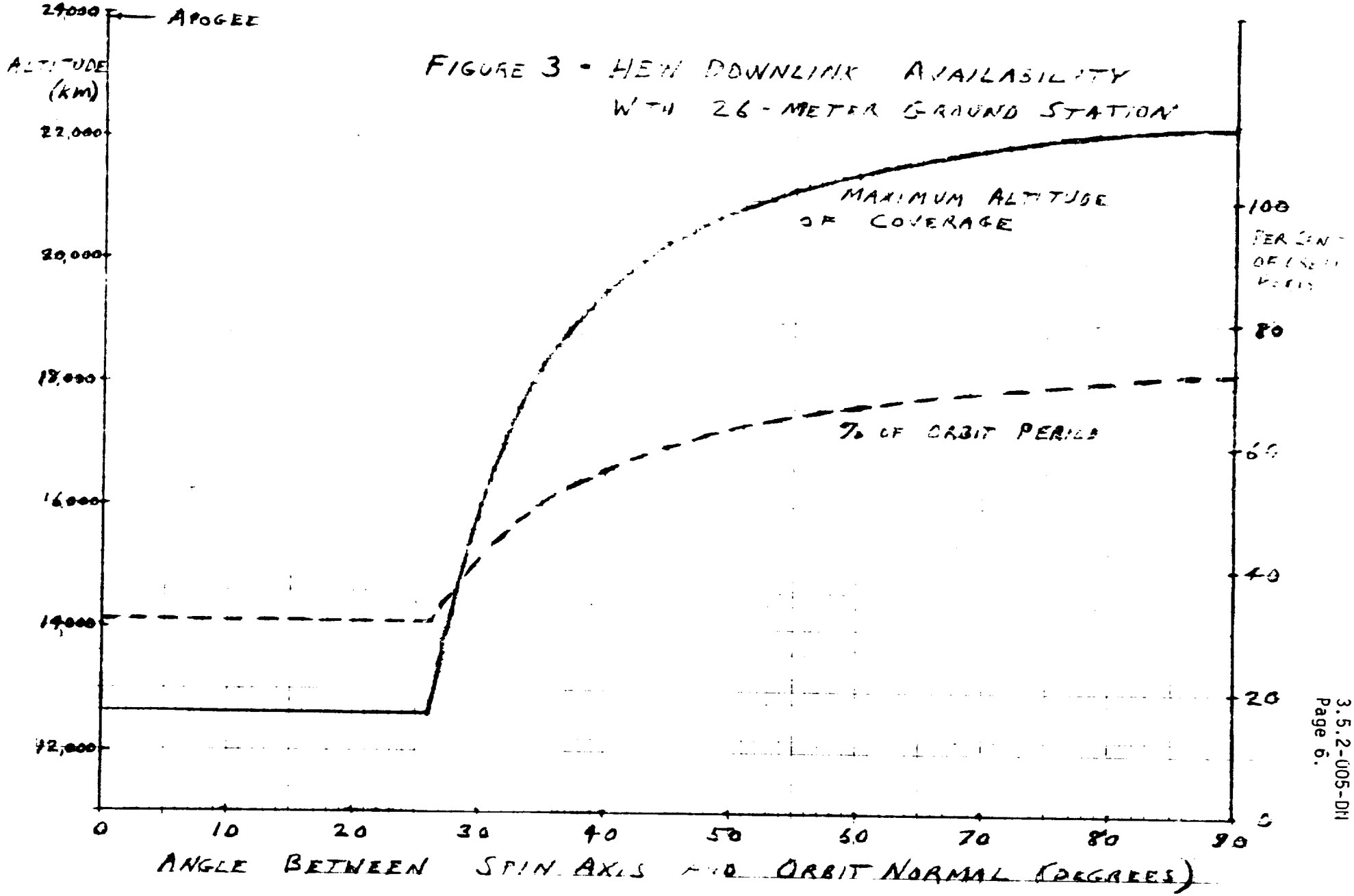


FIGURE 3 - HEW DOWNLINK AVAILABILITY WITH 26-METER GROUND STATION

7.0 PLASMA WAVE INSTRUMENT INTERFACE DEFINITION DESIGN NOTES

TABLE OF CONTENTS

Design Note	Title
4.5.3-034	PWI Testing and Calibration

RCA Astro Electronics Division

Originating Project or Group	File #4.5.3-034
Dynamics Explorer	

Title

PWI Testing and Calibration

Written by: Paul S. Valenzuela	Date 28 Aug 78
Approved by: W. F. Fuldner	Date 28 Aug 78
( ) ( )	

REVISIONS

Letter	Description	Date	Author

V. TESTING AND CALIBRATION

Instruments similar to the PWI Instrument previously described have historically required more spacecraft testing and calibration than most other types of instruments. The following section will attempt to describe the Why's and the How's of that testing and calibration, the equipment used, the support required, and those requirements which conflict or differ with those of the Dynamics Explorer Test Plan for Evaluation and Certification of Instruments (TEC).

1.0 SENSOR STIMULATION AND SPACECRAFT CONNECTIONS

The PWI AGE requires sync signals from the spacecraft for proper operation. These signals will preferably be hardline from the Spacecraft Umbilical. A less desirable method would be to buffer them in the experiment and feed them through the experiment test connector. This latter method requires access to the experiment test connector for all tests requiring AGE stimulation. Assuming the signals are available at the spacecraft umbilical, the only connections between the AGE and the spacecraft will be via the sensor inputs as described below.

1.1 Electric Field Antennas

1.1.1 E_x

These sensors will be driven differentially via the RF test connector located on the antenna housing. This connector should be accessible on a fully configured (Solar Panels, Thermal Blankets, etc.) spacecraft.

1.1.2 E_z

These antennas should also have an accessible RF connector on each unit similar to E_x.

1.1.3 Short Electric Antenna

This antenna is driven differentially via cables that clip to each wire cage. No external shielding of the spheres appears to be necessary due to the low impedance provided by the 40 db attenuators to be described later.

1.2 Magnetic Field Sensors

Both the Loop and Search Coil require magnetic field stimulation and shielding from external interference (60 Hz etc.). To avoid these interference problems, the Loop and Search Coil are calibrated separately and the majority of the spacecraft and subsystem level testing will bypass these sensors themselves and instead will drive their respective differential amplifiers in the main electronics via the boom cabling. This connection is accomplished via a relay circuit that connects either the output of the sensor or the output of the 40 db attenuators to the differential amplifiers. A more detailed discussion of the 40 db attenuators and the sensor bypass relays follows.

1.3 40 db Attenuators

External programmable 40 db attenuators are required on all sensors to attenuate external noise pickup on the sensor stimulus lines at low level signal input. After the input signal level has increased sufficiently ($\simeq$ 10 mV) the attenuation is switched out and the input level decreased by 40 db by control pulses from the AGE stimulus unit. Teledyne magnetic latching relays are used to enable to attenuators to hold state after the power has been removed. Electrically the units appear as either a short from input to output or a 5K - 50Ω resistive divider trimmed to give 40 $\pm$ .2 db attenuation. Attenuators for the E_x and E_z antenna inputs have an additional state which presents a high impedance (1 Meg - 220 pf) to the antenna input during testing of the internal calibration signal. Physically the units are built in aluminum boxes (5.5 x 2.8 x 3.3 cm), with the input and

output stamped into the lid as well as an identifying number. E_x and E_z units have an "S" following the identifying number.

Signal connections are made through Female BNC connectors and control connections through a UMI-5F connector on the side of each box. All units were built to thermal-vacuum specifications and all units to be used for DE project have been through Thermal Vacuum at least twice.

A 40 db attenuator is required on all ten stimulus lines and must be located as close as feasible to the sensor (6" - 12"). The attenuators are small and in the case of the E_x and E_z sensors will necessarily be separated. On previous spacecraft these were tied or taped close to the sensor. In the case of the 40 db attenuators for the boom mounted units, which may be mounted on a plate along with the Magnetic Sensors Bypass Relays described below, provision should be made for rigidly attaching the plate somewhere -- preferably to the boom. Details of this plate will be provided at a later date.

1.4 Magnetic Sensors Bypass Relay

These relays allow the experiment differential input to be driven from either the sensor output or the AGE stimulus output. Switching is done with latching relays, controlled by a manual switch to be located at the AGE equipment rack. The possibility of making the relay control automatically controllable from the AGE computer is under consideration.

Since both magnetic sensors are located on the boom, the Bypass Relays will be mounted on a plate with the 40 db attenuators, and will use the common return for the control ground. This technique cuts down the number

of lines required. Configuration of the plate is TBD.

Prior to any major testing the Bypass Relays adapter cable will be connected between the loop or search coil and their respective cables. A small harness will connect power and thermistor lines continuously, while the signal lines will be brought out to the relay box. The sensors are thus powered at all times during testing, and the experiment input can be switched from sensor drive to stimulus drive and back without shutdown of the experiment to configure the cables manually.

2.0 AGE DESCRIPTION FOR THE DE PWI (see enclosed Block Diagram)

The AGE for the PWI falls into two categories: experiment control for bench level testing and experiment stimulus for all levels of testing.

2.1 Bench Level Testing

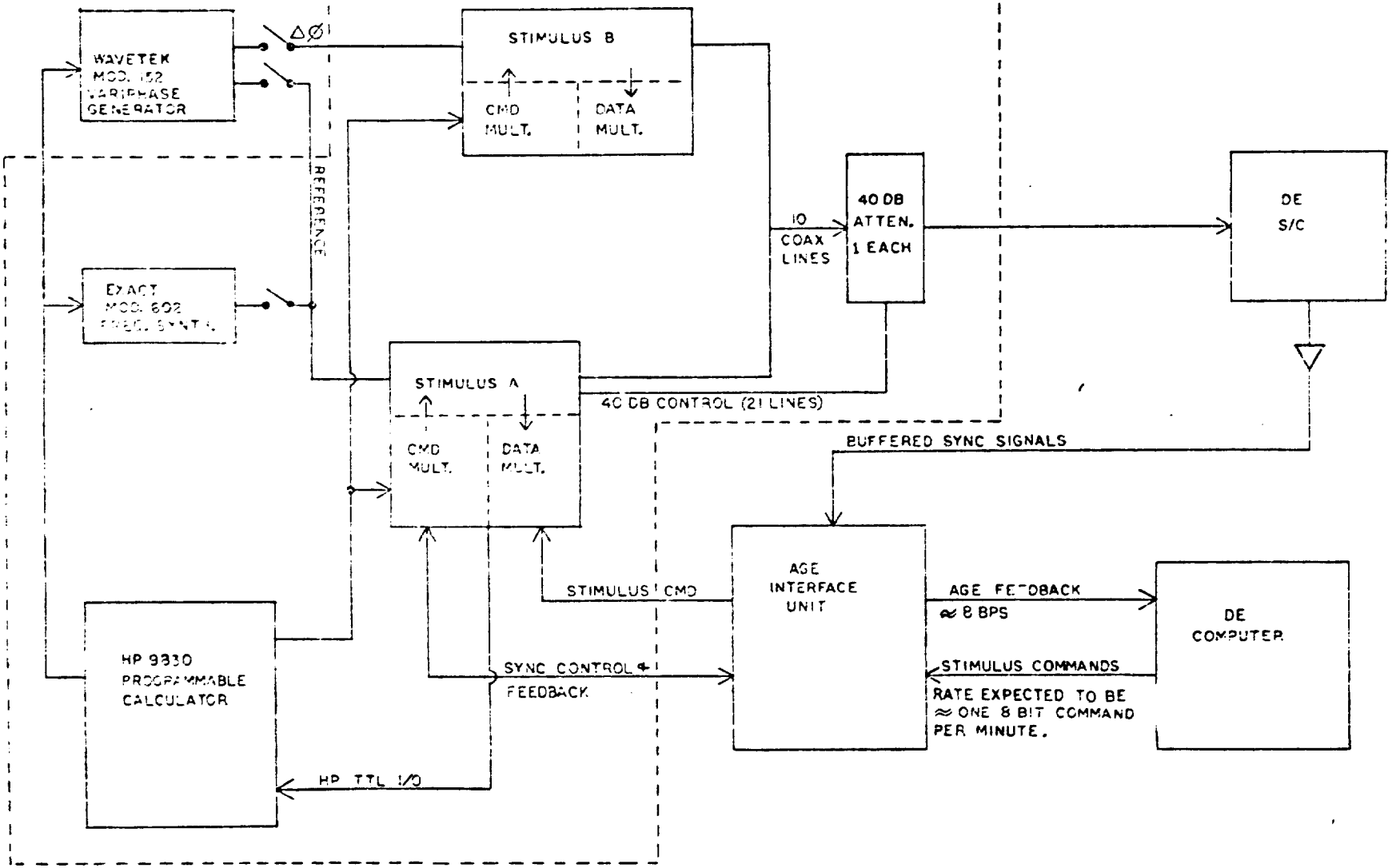
The experiment control section will contain the equipment necessary to command and power the unit and display all digital parameters coming from the experiment. Analog multiplexing will allow any single analog channel to be displayed.

The design of this section is not expected to be fundamentally different from that of the ISEE-A/B or Voyager PWS systems, control being selectable for either manual operation or automatic. Automatic operation will be controlled by an HP-9830 calculator system.

2.2 Experiment Stimulus

The experiment stimulus will be adapted as much as possible from the existing ISEE equipment. Calibration and checkout of the PWI experiment requires the ability to drive an accurately known frequency in the range 1 Hz to 2.040 MHz at a known amplitude (+10 db to -120 db where 0 db = 1V rms), and the capability of producing a known phase difference between two antennas in the frequency range of 1 Hz to 400 kHz.

1. Added comments and designation no. 3/1/77



ALL COMMAND AND DATA HANDLING WILL BE DONE BY THE DE COMPUTER SYSTEM (SIGMA 5).

NOTE: UNLESS OTHERWISE SPECIFIED,

USED ON | CALLED FOR ON

DO NOT SCALE PRINT

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES WITH TOLERANCES ON FRACTIONS DECIMALS ANGLES ±1/64 .XX ± .01 ± 0°15' .XXX ± .005

MATERIAL

FINISH

DRAWN	D. McAnelly	DATE 10/20/77
DESIGNED		
DRAFTING APPROVAL		
MECH DSGN APPROVAL		
ELEC DSGN APPROVAL		11/21/77
OTHER APPROVAL		
PROJECT APPROVAL		11/20/77

UNIVERSITY OF IOWA
DEPT OF PHYSICS & ASTRONOMY
IOWA CITY, IOWA

Proposed DE PWI-AGE for S/C Level Testing Block Diagram

DRAWING IDENTIFICATION

CODE				
02912	83	C	1900	1
SCALE	WEIGHT		SHEET	OF

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To meet the basic amplitude-frequency requirements, the ISEE GSE was developed. This system uses a programmable frequency synthesizer driving programmable attenuators which can be set at 1 db steps in the range of 0 to 110 db. The output of these attenuators is transformer isolated and fed differentially to any one or combination of 5 antennas. Common mode drive is also available by driving both inputs of an antenna from one side of the differential transformer winding.

To achieve lower noise levels, an outboard programmable 40 db attenuator is placed in each antenna line. Ideally these are placed as close to the antenna inputs as possible. To avoid loading the internal calibration signal the outboard attenuators can be switched to and open state where the Ω signal drive is disconnected and the antenna is switched to a high impedance load. On the magnetic antennas provision is being made to be able to either drive the differential amplifier directly or switch to the sensor to observe the calibration signal.

Since a single stimulus unit cannot provide the needed phase differences between antennas, two units will be used for phase calibration, one driven by the reference port and the other by the variable output port of a Wavetek Programmable Variphase generator. Since the stimulus unit outputs will be connected in parallel with no lockout, it is possible to connect both stimulus unit outputs to the same sensor. Assuring the antennas are driven separately will be the responsibility of the operator or the software.

The equipment for the AGE will be contained in two (2) movable racks each about 5 x 2 x 2 ft. During normal testing the racks must be close enough to the S/C to allow the coax signal harness and 40 db attenuator control harness to be properly connected (~ 10 ft.). During environmental testing enough bulkhead connections must be reserved to allow all of these lines into the chamber. Required are:

10 separate coax lines shields must be isolated

21 control harness lines

If feasible we may want to include an optional drive capability for the magnetic sensors. This would create the need for another two coax lines into the chamber and two more control lines.

All AGE hardware with the exception of the following off the shelf or previously purchased items

a. HP9830 Programmable Calculator

b. Exact Mod 602 Programmable Frequency Synthesizer

c. Wavetek Mod 152 Programmable Variphase Generator

are fabricated by the University of Iowa.

2.3 Automated Testing

For on-spacecraft and qualification program testing we propose to use a system similar to that used for ISEE. In this system, a program in the DE computer system will configure the experiment via Major and Minor Mode Command and then send a stimulus command to the PWI AGE calculator. This stimulus command will call a preprogrammed test sequence in the calculator. While the sequence runs, the DE computer system will collect data from the experiment and print it out

along with AGE status information which will be fed back at the same time. When the calculator sequence is completed it will signal the DE computer which will go to the next step of its test sequence.

A minimum AGE interface requires the 1/sec, 64 wd and 128 wd pulses to be buffered and made available to the AGE. This would allow manual operation of the AGE as a stand alone system. Testing efficiency will be greatly increased, however, if the AGE calculator can be controlled directly from the Sigma 5 as described in the previous paragraph.

An 8-bit Transmit and separate 8-bit Receive buss is required as a minimum to implement the Stimulus Command and Feedback System. Data transfer will be simplified, however, if provision is made for additional lines from the AGE to the Sigma 5.

2.4 During the course of normal testing and for certain special testing, we will require access to the analog output of the telemetry receiver for wideband receiver testing. This output will be monitored with several pieces of portable equipment (spectrum analyzer, demodulator, etc.) and does not have to be available at the stimulus racks. Frequently during analog testing we will require a tape recording of the analog output, the recording requirements are TBD.

A separate portable piece of AGE will be developed to monitor the output of the WAVE receiver. This unit will contain a gain state decoder plus a demodulator for the mode when both the WBR and LWR share the analog transmitter.

3.0 TESTING

The following refers to the Dynamics Explorer Test Plan for Evaluation and Certification of Instruments (TEC).

3.1 EPET

An instrument such as the PWI that performs the number of functions (DC and AC electric field measurement to 400 kHz, and AC magnetic field measurement to 400 kHz, plus Phase determination, along with wideband information to 2 MHz, and Linear wideband measurement), with the number of sensors (3 Electric field, 2 Magnetic field), and the number of modes (Automatic or Manual selection of 1 to 5 antennas to 1 of 4 different subsystems in combination with Automatic or Manual selection of 136 different frequencies) cannot receive a complete electric performance evaluation test in one hour as suggested in the TEC document. A comparable experiment on the ISEE A spacecraft never received what could be considered a complete EPET during the six-hour periods allotted it.

We believe the PWI unit, however, can receive a thorough checkout in a 3-hour period assuming no hardware or software malfunctions and a fully automated test procedure. This requires PWI antenna and mode selection, Real time data display, and PWI AGE program call all under Sigma 5 Program Control. A feedback link from the PWI AGE to the Sigma 5 with the feedback information on both the real time display or on-line printout and subsequent off line printout is considered

essential. Absence of any of the above capabilities will significantly increase the required test time.

The instrument cannot be checked solely from the PWI test connector* as there is no provision for commanding through the test connector. In addition all the required Analog and Digital outputs are not available at the Test Connector and even assuming that they were, the AGE is incapable of displaying a full data frame and has no data storage capability. Much of our EPET procedure will utilize the fact that two or more sections of the instrument can be tested simultaneously assuming the entire data frame is being collected and displayed or stored for later printout.

APT -- An abbreviated performance test utilizing the calibration feature of the instrument could be done in ≈ TBD.

3.2 Testing Sequence

We would prefer a testing sequence that differs somewhat from that in the TEC. Traditionally our instruments are temperature tested at Iowa and then taken to GSFC for EMI and Magnetics and perhaps preliminary weight checks. The instrument is then returned to Iowa for final conformal coat prior to vibration at Iowa. Following vibration, it is returned to GSFC for Thermal Vacuum. The rationale for this is that we do not have the facilities at Iowa for either EMI or Magnetic preliminary testing. This means we do not know until the tests at Goddard if we are out of spec. If rework is required, it is much simpler to do it on a unit with subsystems that are relatively accessible. Thermal vacuum testing does not present this problem as vacuum has

*Recent conversations with M. Lidston modify this statement somewhat. During unit level tests at GSFC theinstrument can be tested when the simulator is disconnected as this is no different than a bench test configuration with possibly longer cables. The statement concerning data display and storage is still valid and the paragraph still holds for on-spacecraft testing.

little effect on the operation of the instrument and the unit will have been thoroughly temperature tested at this point.

Our preferable sequence would then be

Mechanical Interface EMI Magnetics	}	GSFC
Vibration	–	Iowa
Weight - Pyro Shock Acceleration Thermal Vacuum	}	GSFC

3.3 Further Comments

A. The 3' × 3' chamber will not accommodate the loop antenna. A chamber of at least 4' × 4' or more will be required.

B. A thermal balance test of the boom mounted units will be required.

C. If an extendible type boom is to be used, some sort of stub boom for mounting the loop, search coil and short electric antenna must be developed. This unit must be designed to fold to meet the shroud profile and to orient the sensors in their proper position when deployed. If the decision is to fund the University to design and build this stub boom, some sort of deployment test will be required that most likely will have to be done at GSFC.

D. We believe that from both a cost and schedule standpoint the PWI vibration testing should be done at Iowa. A listing of the vibration facility's instrumentation follows. This facility was used for testing experiments for the Injun V, Hawkeye, IMP H, IMP I, IMP J, Helios, MJS, and ISEE programs.

U OF I PHYSICS DEPARTMENT
VIBRATION FACILITY

GENERAL DESCRIPTION:

The U of I facility provides for sine vibration testing as follows:

Frequency	-	5 - 2000 Hz
Control	-	servo with constant displacement, velocity or acceleration.
Maximum displacement	-	.8 in D.A.
Maximum Force	-	approx. 2500 lb.
Maximum Acceleration	-	100 g
Table Weight	-	21 lb.

The random facility is as follows:

Frequency	-	20 - 2000 Hz
Equalization	-	Manual, 45 channels
Analysis	-	PSD with single channel sweeping analyzer (BW = 10 Hz and 50 Hz)
Display	-	PSD on X-Y recorder

EQUIPMENT LISTING:

1 - B & K 1025 servo/sine oscillator
4 - U - D, D11 series charge accelerometer preamps
1 - U - D, MAC-6C multifunction averaging control
1 - S - D, SD101A analyzer/tracking filter
1 - Ballantine 320 RMS voltmeter
1 - HP 7562A Log voltmeter
1 - HP 7005B X-Y recorder
1 - U - D, E109 spectrum equalizer
1 - Krohn-Hite, 330M B.P. filter
1 - GR, 1390-B noise generator
1 - Ling, PP-7/8-C power amp, 7 KVA
1 - U - D, 203 AMA shaker

Manufacturer Abbreviations

B & K	-	Bruel & Kjaer
U - D	-	Unholtz - Dickie
S - D	-	Spectral Dynamics
H - P	-	Hewlett Packard
GR	-	General Radio

4.0 CALIBRATION

Calibration of the instrument is normally done during spacecraft Thermal Vacuum Testing due to the fact that only at that time are all the factors present that can affect the system end output. These are

1) loading of the sensor outputs by interconnecting harnesses,

2) temperature variations,

3) spacecraft generated interference,

4) analog to digital conversion quantization errors.

Calibration is a time consuming process and depending on the extent could require 24 hours or more at each temperature.

Other options with their associated drawbacks are being considered:

A. Part of the calibration is done at one temperature soak and the remainder at ambient and the opposite temperature extreme.

B. The calibration is done on the spacecraft but not necessarily during thermal vacuum. This would require a 24-30 hour period where PWI calibration had highest priority. In the case of 8-hour days only, 3-5 days. I would assume this would be in the evening.

C. The calibration is done during subsystem Thermal Vacuum.

D. Calibration is done at Iowa and only selected channels, levels, etc. to verify those previous calibrations or perhaps determine where loading occurs would be done during spacecraft thermal vacuum testing.

In addition to routine testing and calibration, certain one-time-only tests are required to insure proper operation, tolerable interference levels, etc. Following is a description of those tests.

PWI (Plasma Wave Investigation)
INSTRUMENT UNIQUE TESTS

The following is a description of the special one-time-only or infrequently run tests that we feel are necessary to insure tolerable interference lvels and proper operation and understanding of the PWI instrument and related spacecraft systems. Similar tests have been carried out within the Injun, IMP, Hawkeye and ISEE programs. It is very likely that most of these tests can be phased in with the spacecraft integration and check-out.

1. EMI VERIFICATION TEST

This test is intended to locate radiated and/or conducted electrical interference from the spacecraft systems or other instruments that might not have been detected at the unit or spacecraft EMI test level. The test must be conducted in a shielded room. The capability of physically removing all 60 Hz input from the room either by removing fuses or throwing knife switches, etc. is important. We have found in the past that it is necessary to operate the spacecraft on external batteries to achieve the noise level required for meaningful testing. In its final version the test requires a fully configured and completely buttoned up spacecraft such as it would be for the spacecraft EMI test, but a modified test earlier in the program

(a preliminary conducted interference test could be run in the clean room or an open spacecraft) would point out problem areas. The standard procedure in this type of test is to power down to only essential spacecraft systems for a baseline and then sequentially turn on all instruments and spacecraft systems in their most noisy mode and look for an increase in the PWI instrument noise level. This test could be conducted in conjunction with the standard EMI tests.

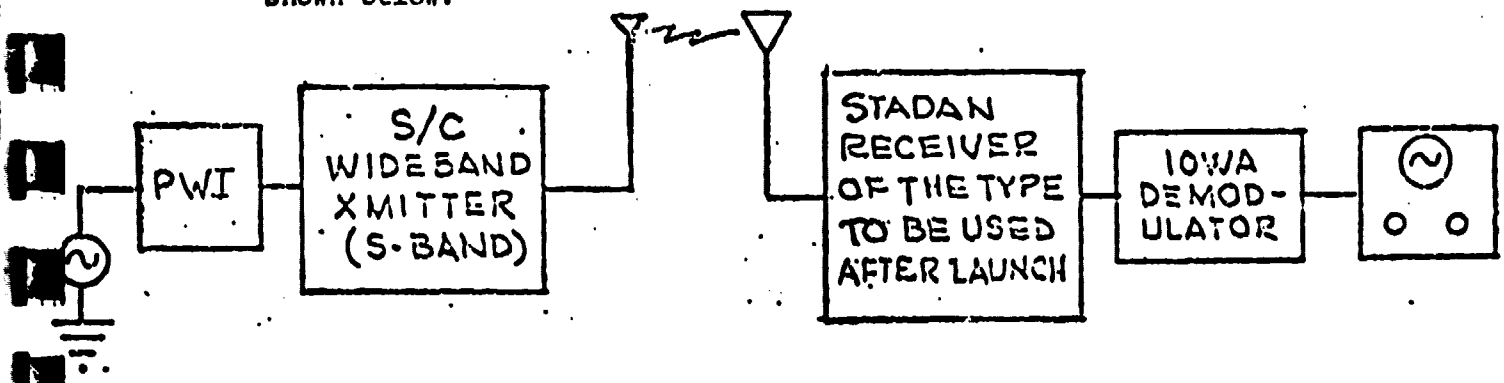
2. SOLAR ARRAY NOISE MEASUREMENT

High level noise present on the solar array buss due to regulator switching and the inherent ripple as the panels come into sunlight could conceivably be coupled to the PWI antennas. Since this noise, especially in the case of the regulator, is a function of the illuminated array impedance which is difficult to simulate, the only accurate means of knowing it is to measure thenoise on the solar array buss of a fully configured spacecraft spinning in sunlight. We would do so by capacitively coupling the buss to one of the electric preamps using the PWI instrument then as a spectrum analyzer. If a spinning test is impossible we would at least want to run the test on a stationary illuminated spacecraft.

3. SETTING OF MODULATION INDEX

The purpose of this test is to accurately adjust the wideband output peak-to-peak signal level to obtain maximum deviation of the carrier without distortion as determined by observing the real time

demodulated signal after it has passed through the entire system as shown below.



Our PWI instrument will be constructed to make the gain adjustment easily available through an access hole on the main electronics box front plate. When this adjustment was made on previous experiments the spacecraft was located in building 22 and the demodulator at the output of the STADAN receiver at NTTF so it will require a certain amount of coordination such as communication between the two areas, etc. The test does not require a fully configured spacecraft but only those systems essential for wideband transmission.

4. LOW FREQUENCY MAGNETIC EMI

The purpose of this test is to locate any magnetic field interference generated by spacecraft subsystems or other experiments. This test can only be done at the Magnetic Test Facility and requires all AC power in the area be shut down. This power restriction also applies to the S/C power and any support equipment. This requirement can be met by powering the S/C from internal or external batteries and transmitting the data to a suitable receiver tied into the EE data handling system. The test requires a fully configured spacecraft. The

standard procedure is to power down to only essential spacecraft systems to obtain a baseline and then sequentially turn on all instruments and spacecraft systems in their most noisy mode and look for an increase in the baseline readings from the PWI instrument print out.

5. PWI PHASE/AMPLITUDE CALIBRATION

This test is required to determine the phase differences, as a function of frequency and amplitude, between each pair of antennas -- loop, search coils and electric dipoles. Measurements are made from the antennas through the data handling system. The spacecraft must be in a magnetically quiet area such as the Magnetic Test Site. The test does not require a fully configured spacecraft but only the PWI experiment and associated spacecraft data handling systems -- transmitter, receiver and Sigma 5 computer. The power needed will most likely require the use of automobile storage batteries. The batteries should be fused and placed in battery boxes in such a way that it is impossible to short them out. The University can supply these batteries but with the shipping etc. required it would be more economical if they were supplied by GSFC. All electrical power in the area must be off or DC operated including spacecraft support equipment as in the low frequency EMI Test (#4). A battery powered signal generator will drive all of the antennas and the phase variations between antenna pairs as a function of frequency and amplitude will be read out from the PWI Instrument data output.

6. COMPRESSOR TIME CONSTANT CALIBRATION

A. Purpose--To calibrate the phase shift of signals through the compressors (for radio source direction finding corrections).

B. Location and Configuration--The Clean Room environment will be sufficient for this test as the Magentic Sensors will be bypassed. The test does not require a fully configured spacecraft but only the essential subsystems: data handling, power, etc.

C. Special Equipment Needed--Will be furnished by Iowa.

D. Special Timing Signals Needed--We will require a Nadir pulse to our AGE and to the S/C to simulate optical aspect data (this pulse must be at ≈ the S/C spin rate but not an exact multiple of any telemetry clock rate).

E. Procedure--The input signal to the experiment will be AM modulated by a sine wave derived from the sun pulse and uniquely correlated to it (say the signal minimum occurs at sector 0). Plotting the compressor output against sector will then give the phase shift of the compressors. This test should require ≈ 4 hr. exclusive of setup and check out.

F. Frequency--The test should be run 2 separate times for comparison and accuracy check. The test will take ~ 4 hours.

Dr. Helliwell's group at Stanford may also require special testing for the LWR but such test requirements will be supplied and supported by them and do not appear in this document.